SOURCES OF DYNAMIC MACROECONOMIC FLUCTUATIONS IN SMALL OPEN ECONOMIES: THE CASE OF TAIWAN

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Submitted to the faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 2003

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ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my major advisor, Dr. Dan Rickman for his intelligent supervision, constructive guidance, inspiration and friendship and special gratitude to my advisor, Dr. Frank Steindl, for his deliberate review and refining of my dissertation. My sincere appreciation extends to my other committee members Dr. Lee Adkins, and Dr. Dan Tilley, whose guidance, assistance, encouragement and friendship are also invaluable. I would like to thank Department Head, Dr. Keith Willett, Department Secretary, Ruby Ladd and the Department of Economics for providing me with this research opportunity, assistance and their generous financial support. More over, I wish to express my sincere appreciation to all the professors in Business College.

I would like to give my appreciation to my Parents, Wei-Hsiung Liu and Chen-Mei Chang, without their financial and mental support, I would not have this chance to pursue my Ph.D. degree. I would also like to give my special gratitude to my wife, Hsinhua Chuang, and my brothers and sister for their support during my study in OSU.

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CHAPTER 1

INTRODUCTION

The macroeconomic cycle is an attractive subject of study in the field of economics. Identifying the sources of business cycle fluctuations is an important step for macroeconomic policy making. Most economic textbooks agree that the economic cycle is the result of variations to the equilibrium of aggregate supply (AS) and aggregate demand (AD) functions of an economy. However, there are still debates on macroeconomic theories. In general, classical and new classical theories do not allow the possibility that except for surprises, output can deviate from capacity for very short intervals if the price level can adjust so quickly as to eliminate the gap between AS and AD. On the other hand, Keynesian economists contend that the presence of market imperfection (i.e., nominal rigidities, regulation restrictions, as well as market immobility, etc.) makes room for phenomena that could potentially explain most short-run fluctuations in GNP, and that can not captured by equilibrium models.

Keynesian theories indicate that in the short run the effective demand of economic agents determines the level of output produced, yet there may exist disequilibrium in the economy if price flexibility and the mobility of markets are not sufficient to eliminate the gap between aggregate supply and aggregate demand at that time period. During the disequilibrium, the economic agents who perceived the gap slowly adjust their behavior to eliminate the deviation back to the long run equilibrium for the following periods. This is the so-called economic cycle. In order to capture this feature, error correction mechanisms, known as error correction models, were developed to reconcile the short-and long-run behavior of economic variables. In recent years, distributed lag theory has been gaining popularity. The principle behind this is that there often exists a long-run equilibrium relationship among economic variables. In the short run, however, there may be disequilibrium. With error correction mechanisms, a proportion of the disequilibrium in that period is corrected in the next period because economic agents cannot be aware of the current economic situation until information is available during next period (e.g., lagged information, adjustment bias and expectational mechanism). For instance, the excess demand may be corrected by the change of price level in the next period, and the change of income may influence the change of consumption in the next period.

Most economic theories explain that the reason economic variables deviate from their long-run equilibrium in the short-run is that there exist unanticipated economic shocks that impact the markets of an economy in a propagation mechanism. The propagation impulse framework has come to dominate the analysis of economic fluctuations. In this mechanism, Slutsky (1937) indicated, the fluctuation is the result of small and large, white noise shocks--impulses-- that affect the economy through a complex dynamic propagation system. Incorporated with the idea of an error correction mechanism, the propagation theme can be captured by the vector autoregression model developed by Sims (1980). The VAR is a reduced-form time series model of the economy that is estimated by ordinary least squares. Initial interest in VARs arose because economists could not agree on the economy's true structure. VAR users thought that the models could reveal important dynamic characteristics of the economy without imposing structural restrictions from a particular economic theory. As Sims indicated, impulse response functions and variance decompositions illustrate the dynamic characteristics of empirical models. Some economists believed that these two dynamic components were unrelated to economic theories. However, Cooley and LeRoy (1985) argued that this method, which is often described as atheoretical, actually implies a particular economic structure that is difficult to reconcile with economic theory.

This criticism leads to the development of a Structural VAR approach by Bernanke (1986), Blanchard and Watson (1986), Sims (1986), and others. The crucial difference between atheoretical and structural VARs is that the latter yield impulse response functions and variance decompositions that can be given structural interpretations. This technique allows the researcher to use different economic theories to transform the reduced form VAR residuals into the structural identification by imposing a system of structural contemporaneous/or long run restrictions. The estimation of these contemporaneous equations is used to transform reduced-form residuals into structural innovations. On the other hand, Shapiro and Watson (1988), Blanchard and Quah (1989) utilized long-run restrictions to identify the economic structure from the reduced form. Their model demonstrates long-run characteristics that are consistent with theoretical restrictions used to identify parameters as well as sensible short-run properties.

Blanchard and Watson (1986, p.124) indicate that research on impulse mechanisms centered on two main categories. The first concerned the number of impulses: was there only one source of shocks to the economy or many? Monetarists often singled out monetary shocks as the main source of business fluctuations. This theme had been empirically examined by many dynamic factor analysis models. The alternative view that there were many important sources of shocks was echoed by many researchers, such as Blanchard and Quah (1989), Gamber and Joutz (1993), and Karras (1993).

The second question concerns how the shocks lead to fluctuations. One view is that the accumulation of small, seemingly unimportant shocks can lead to economic fluctuations similar to the fluctuations caused by infrequent large shocks. That is, the accumulation of small shocks could generate data that mimic the fluctuations of macroeconomic time series. The other view, which underlies many policy discussions, is that there are infrequent large identifiable shocks that dominate all others. Blanchard and Watson (1986) indicated that economic fluctuations can be ascribed to particular large shocks amid the return of the economic variables to their equilibrium in the following periods.

Blanchard and Watson use two approaches to examine the two questions. The first approach specifies and estimates a structural model, and examines the characteristics of the shocks as well as calculates their contributions to economic fluctuations. They concluded that fluctuations are due to fiscal, money, demand, and supply shocks in roughly equal proportions. Their model shows evidence against the small-shock hypothesis.

Their second approach tests one of the implications of the small-shock hypothesis. The idea is that if economic fluctuations arise from an accumulation of small shocks, business cycles must be alike to some extent. Their conclusion is that business cycles are not all alike. But they indicated that the conclusion is not strongly against the small-shock hypothesis; instead, it just provides mild support in favor of the view that large specific events dominate individual cycles. Blanchard and Watson (1986, p.125) also indicate that the primary concern is not an economy characterized by large shocks and a gradual return to equilibrium, but rather an economy with infrequent large shocks as well as many small shocks.

Providing that structural VARs may unlock economic information embedded in the reduced-form time series model, one can construct contemporaneous structural equations based on most accepted macroeconomic theories to find the variables that cause the economic cycles. Even though there is considerable disagreement and debate, as Karras (1993, p.48) indicates, "most macroeconomists today would agree with the following propositions: (1) aggregate supply disturbances have permanent effects on output, (2) aggregate demand disturbances have mainly temporary (short- and medium-term) effects on output, (3) aggregate demand and supply disturbances affect inflation in the short run, and (4) inflation is a monetary phenomenon in the long run." Therefore using structural equations with macroeconomic constraints based on most accepted propositions, one can find the orthogonal structural shocks derived from the just identifying structural equations to construct the dynamic innovations of the variables. By employing the so-called structural vector autoregression (SVAR) technique, this paper tries to identify those variables that impact Taiwan's economy and to construct the dynamic innovations caused by these variables. In Chapter two, we introduce the theoretical background of structural VAR. In Chapter three, we review the economic development of Taiwan from 1971 to 1981. In Chapter four, we review the Karras model using oil, fiscal, (non-oil) aggregate supply, monetary, (non-fiscal, non-monetary) aggregate demand, and exchange rate shocks for the case of U.S. and extend his research to 2001. In Chapter five, we also compare the Choleski model with the restricted and original Karras models for the case of Taiwan. Based on the restricted Karras model, Chapter six and seven investigate and compare the importance of the six shocks for Japan and Korea. Chapter eight compares the four countries and gives a conclusion.

CHAPTER 2

LITERATURE REVIEW AND METHODOLOGY

2.1 From Structural Equations to Vector Autoregression—Sims's Criticism

General statistical models usually estimate the exogenous parameters for the estimation of interested endogenous variables based on a sound theoretical background. This statistical method however may fail to identify the estimators of each exogenous variable when the so-called exogenous variables are to some extent correlated with each other. General economic models treat economic variables as random or stochastic variables whose properties can be described by probability distributions. Most conceptual frameworks for understanding economic processes and institutions recognize that there is a feedback between economic variables and that in economics everything depends on everything else. This translates into the realization that economic data that are the product of the existing economic system must then be described as a system of simultaneous relations among the random economic variables and that these relations involve current, future, and past (lagged) values of some of the variables. For this reason, Marschak (1950) contended that economic data are generated by systems of relations that are generally stochastic, dynamic and simultaneous. The doubt on exogeneity of economic variables had gained attention and led to the development of large-scale models based on macroeconomic restrictions to identify the parameters of the interested variables.

When contemporaneous correlation exists, it may be more efficient to estimate all equations jointly, rather than to estimate each separately. In dealing with large-scale models, statistical theories say that a model is identified if the distinct pattern of the parameters of the model's variables is well recognized based on economic theories (which is usually what we mean by a structural form for a model). If the parameterization we derived from economic theories fails to be identified, we can transform the structural equations into reduced form instead. This is called normalization. However, through normalization, Sims (1980) commented that the individual equations of the model are not products of distinct operation in economic theory.

Instead of using reduced form, many economists normalize the large-scale models by requiring that the residuals of the model be orthogonal across equations and the coefficient matrix of current endogenous variables be triangular. Sims (1986, p.11) indicates that the parameter space of this model is acquired if its normalization into a Wold causal chain form is identified. This results in equations that are linear combinations of the reduced form equations. But Sims (1980, p.3) emphasizes the danger of one-equation-at-a-time specification of a large macroeconomic model. He indicates that the distinctions among equations in large macroeconomic models are normalization, rather than truly structural distinctions.

In addition, Sims (1980, p.4) also emphasizes that macroeconomic models have rich sources of dynamic elements. He argues that the extent of rich sources of dynamic elements may weaken the few legitimate bases for generating identifying restrictions for the structural economic models. He contends that business behavior, when markets do not clear, must depend not only on hypothetical business demands and supplies given current prices, but also on the excess demand of Walrasian theory. This means that we cannot suppose that business behavior is invariant under changes in the public's taste. For example, if the excess demand or supply in the money markets enters the money supply decision of the Central Bank, the excess supply or demand of money acknowledged by business agents may also influence the dynamic money demand equation.

Besides, Sims also indicated that rational behavior under uncertainty of business agents is likely to undermine the exclusion restriction that econometricians had been used to thinking of as reliable. For example, as Sims (1980, p.6) explains, "however certain we are that the tastes of consumers in the U.S. are unaffected by the temperature (e.g. frost) in Brazil, it is possible that U.S. consumers might attempt to stockpile coffee in anticipation of the frost effect on price." Moreover, the change of a macroeconomic policy variable, as Lucas's critique showed (1977), is a rule for systematically changing that variable in response to market conditions, therefore institution of a nontrivial policy would end the exogeneity and change the expectation formation rule and the normalized reduced form.

In summary, Sims (1980) proposed three criticisms of large-scale structural models: (1) most of the restrictions on structural models are false, and the models are nominally over-identified. That is, the restrictions on the structural model are neither unique nor distinct, if the so called exogeneity is in fact endogenous; (2) the rich sources of dynamic elements may undermine the legitimate restrictions when applied in identifying structural models; (3) under rational expectations, the change of policy variables as well as economic knowledge may also influence the behavior and anticipation of business agents. Sims's criticism on large-scale macromodels led to the development of vector autoregression models for macroeconomic modeling. Sims proposed that even though most of the restrictions on existing models are false, and the models are nominally over-identified, it should be feasible to estimate large-scale macromodels as unrestricted reduced forms, treating all variables as endogenous (i.e., without restrictions based on supposed a priori knowledge). He admitted that the reduced form will be affected by false restrictions and may become useless as a framework within which to do formal statistical tests of competing macroeconomic theories. But, he indicated, much recent theoretical work shows that the resulting infection need not distort the results of forecasting and policy analyses with the reduced form.

2.2 From Vector Autoregression to Structural Vector Autoregression

VAR models have been popularized by Sims (1980, 1986) and many others. The hallmark of VARs is innovation accounting and error variance decomposition. Innovation accounting (or impulse response) refers to tracing the system's reaction to a shock (innovation) in one of the variables. For example, in a system of consumption and income, the effect of an increase of income may be of interest. We can trace out what happens to consumption if there is a one-unit increase of income in period zero and vice versa.

Cooley and LeRoy (1985), however, criticized the atheoretical VAR method, mainly for its imposing theoretically improper restrictions. Thus, structural VAR was developed to come to its rescue. The structural VAR approach is a modification of the atheoretical VAR approach developed by Sims (1980). Since then, many researchers have studied how to identify the restrictions that have sound theoretical meaning so as to recover the structural shocks. Sims (1986) proposed that the structural orthorgonalized innovations transformed from the estimated VAR residuals could be partly interpreted as the structural shocks such as policy regime changes. Bernanke (1986), Blanchard and Watson (1986), Blanchard (1989), Karras (1993), and Ahmed and Murthy (1994) estimated the unconstrained reduced form and use a set of just-identifying restrictions to transform the reduced-form innovations to a set of uncorrelated structural innovations. They use the identifying restrictions to give explicit structural interpretations. On the other hand, Shapiro and Watson (1988), Blanchard and Quah (1989), Gamber and Joutz (1993) assumed that demand disturbances affect output in the short run but have no long-run output effect, and supply disturbances have long-run effects on output. As long as these restrictions are not over identifying, the same two-step approach can be used, along with the unconstrained reduced form in the first step, to identify the structural innovations.

The structural VAR model, as shown by Keating (1992), is a simultaneous equations system that models the dynamic relationship between endogenous and exogenous variables. A vector equation of the general SVAR system, divided into contemporaneous endogenous variables and disturbances u_t as well as lagged endogenous variables X_{t-1}, can be expressed as

(2-1) $$AX_t = \sum_{i=1}^{k} C_i X_{t-i} + Du_t,$$

where u_t is a vector of unobservable variables, which are disturbances to the contemporaneous structural equations. The square matrix, A, are the structural parameters on the contemporaneous endogenous variables. C_i is the *ith* square matrix polynomial in the lagged endogenous variables.

The matrix D measures the contemporaneous response of endogenous variables to the exogenous variables if these exogenous variables are observable, or disturbances if not. In theory, observable exogenous variables typically do not appear in VARs because Sims (1980) argued strongly against exogeneity. Therefore, u_t are interpreted as disturbances to the structural equations. A reduced form for this system is

(2-2) $$X_t = A^{-1}\sum_{i=1}^{k} C_i X_{t-i} + A^{-1} D u_t .$$

A particular structural specification for the disturbance u is required to obtain a VAR representation. If the structural disturbances (shocks) have temporary effects, u_t equals ε_t, a serially uncorrelated white noise vector

(2-3) $$u_t = \varepsilon_t .$$

In theory the individual elements may be contemporaneously correlated; however, in the structural VAR process, they are typically assumed to be independent.

Alternatively, the structural disturbances may have permanent effects on endogenous variables. In this case, u has a unit root process, that is

(2-4) $$u_t - u_{t-1} = \varepsilon_t .$$

Equation (2-4) implies that u equals the sum of all past and present realizations of ε. Hence, shocks to u are permanent.

Under the assumption that exogenous shocks have only temporary effects, equation (2-2) can be rewritten as

(2-5) $$X_t = \sum_{i=1}^{k} B_i X_{t-i} + z_t,$$

where $\sum_{i=1}^{k} B_i = A^{-1} \sum_{i=1}^{k} C_i$ and $z_t = A^{-1} D\varepsilon_t$. The equation system in equation (2-5) is a VAR representation of the structural model. The last term in equation (2-5) is serially uncorrelated and each variable is a function of the lagged values of all the variables. The VAR representation matrix, $\sum_{i=1}^{k} B_i$, is a nonlinear function of the contemporaneous and the dynamic structural parameters.

If the shocks have permanent effects, the VAR model is obtained by inserting equation (2-4) into equation (2-2) and by applying the first difference operator ($\Delta = 1-L$) to the equation. We obtain

(2-6) $$\Delta X_t = \sum_{i=1}^{k} B_i \Delta X_{t-i} + z_t.$$

This is also a VAR specification if we can test that macroeconomic time series variables appear to have a unit root. This indicates that if the variables are stationary, equation (2-5) is used; if the variables appear to be a unit root, equation (2-6) is used to estimate the parameters. If some variables have temporary effects, while others have permanent effects, the selected VAR model has to reflect this feature. For example, Blanchard and Quah (1989) estimated a VAR model by assuming some variables have unit roots while others are stationary. On the other hand, King, Plosser, Stock and Watson (1991) use the feature that some linear combinations of the variables are stationary even though all variables have unit roots.

From equation (2-5) or (2-6), we know that as long as we can estimate the VAR coefficient $\sum_{i=1}^{k} B_i$ and proper lags of k, as well as contemporaneous parameters in A and D, we can calculate the behavior of parameters interested by converting the following equations

(2-7) $$\sum_{i=1}^{k} B_i = A^{-1} \sum_{i=1}^{k} C_i .$$

(2-8) $$\varepsilon_t = D^{-1} A z_t .$$

That is, $\sum_{i=1}^{k} C_i$ could be calculated from the estimated VAR coefficients $\sum_{i=1}^{k} B_i$. The structural shocks ε_t could be derived from the estimated residuals z_t. Furthermore, the covariance matrix for the residuals, $\sum_z$ from either equation (2-5) or equation (2-6) is

(2-9) $$\sum_z = E[z_t z_t^{'}] = A^{-1} D E[\varepsilon_t \varepsilon_t^{'}] D^{'} A^{'-1} = A^{-1} D \sum_\varepsilon D^{'} A^{'-1},$$

where E is the expectation operator, and $\sum_\varepsilon$ is the covariance matrix for the shocks.

The estimation of VAR equation (2-5) or equation (2-6) can provide an estimate of $\sum_z$. $\sum_z$ can be used for the estimation of A, D and $\sum_\varepsilon$ based on equation (2-9). For n variables in a structural VAR model, we have $n(n+1)/2$ unique elements in the symmetric matrix $\sum_z$. Likewise, we have n^2 elements in matrix A and D respectively, and $n(n+1)/2$ unique elements in $\sum_\varepsilon$ have to be solved according to equation (2-9). Thus the total unsolved elements on the structural VAR model are $2n^2 + n(n+1)/2$.

The maximum number of structural parameters has to be equal to the number of unique elements (i.e., $n(n+1)/2$) in $\sum_z$. Besides, we have $2n^2$ plus $n(n+1)/2$ unknown elements to be solved. This means that at least $2n^2$ restrictions must be imposed on matrix A, D, and $\sum_\varepsilon$. Typically, we specify $\sum_\varepsilon$ as a diagonal matrix since the structural disturbances are assumed to be independent. This gives n^2 restrictions on equation (2-9). In addition, we can normalize the structural equations to make matrix A have diagonal elements equal to unity. The matrix D has the same specification as A since each equation has structural shocks. This gives an additional $2n$ restrictions. Therefore identification requires at least $3n(n-1)/2$[1] restrictions based on economic theory. If D is taken to be the identity matrix, we can have at least $n(n-1)/2$ additional identifying restrictions to be imposed on A.

Structural VAR model methodology requires a two-step procedure. First, employing the ordinary least squares technique, we estimate the VAR model with proper lags of each variable to eliminate the serial correlation from the residual. Next, we use a sufficient number of restrictions imposed on matrix A, D, and $\sum_\varepsilon$ to identify these parameters based on equation (2-9).

After the structural parameters are estimated, we can derive the dynamic responses of the variables to the shocks by impulse response functions and variance decomposition functions. This is known as the moving average representation (MAR). For example, take the VAR model in equation (2-5) rewritten as

$$X_t = B(L)X_{t-1} + z_t,$$

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[1] This number is derived from $2n^2 + n(n+1)/2 - n^2 - 2n = 3n(n-1)/2$.

where L is the lag operator. Subtract $B(L)X_{t-1}$ from both sides of this equation

$$X_t - B(L)X_{t-1} = z_t,$$

or

$$[I - B(L)L]X_t = z_t.$$

Multiply both sides of this equation by $[I - B(L)L]^{-1}$

$$X_t = [I - B(L)L]^{-1} z_t.$$

From equation (2-8), we have $z_t = A^{-1}D\varepsilon_t$. Substituting into the above equation we get

(2-10) $$X_t = [I - B(L)L]^{-1} A^{-1} D\varepsilon_t = \sum_{i=0}^{\infty} \theta_i L^i \varepsilon_{t-i},$$

where each θ_i is an $n \times n$ matrix of parameters from the structural model.

Equation (2-10) indicates that the response of x_{t+i} to ε_t is θ_i. Hence, the sequence of θ_i from $i = 0, 1, 2, \ldots$, illustrates the dynamic response of the variables x_t to the shocks. If the variables in x are stationary, then the impulse responses must approach zero as i become large.

Variance decompositions measure the quantitative effect that the shocks have on the variables. It decomposes each variable's forecast error variance into the individual shocks. If $E_{t-j}x_t$ is the expected value of x_t based on all information available at time $t - j$, the forecast error is

$$x_t - E_{t-j}x_t = \sum_{i=0}^{j-1} \theta_i \varepsilon_{t-i}.$$

The information at time $t-j$ includes all ε occurring at or before time $t-j$ and the conditional expectation of future ε is zero because the shocks are serially uncorrelated. The forecast error variances for the individual series are the diagonal elements in the following matrix

$$E[(x_t - E_{t-j}x_t)(x_t - E_{t-j}x_t)'] = \sum_{i=0}^{j-1} \theta_i \Sigma_\varepsilon \theta_i' .$$

If θ_{ivs} is the (*v*, *s*) element in θ_i and σ_s is the standard deviation for disturbance *s* (*s* = *1, 2, ..., n*), the *j*-step-ahead forecast error variance of the *vth* variable is

$$E(x_{vt} - E_{t-j}x_{vt})^2 = \sum_{i=0}^{j-1}\sum_{s=1}^{n} \theta_{ivs}^2 \sigma_s^2 .$$

The variance decomposition function (VDF) derives the j-step-ahead percentage of forecast error variance for variable *v* attributable to the *kth* shock

(2-11) $$VDF(v,k,j) = \frac{\sum_{i=0}^{j-1} \theta_{ivk}^2 \sigma_k^2}{\sum_{i=0}^{j-1}\sum_{s=1}^{n} \theta_{ivs}^2 \sigma_s^2} .$$

The same analysis can be used in equation (6). As shown in equation (10), we have

(2-12) $$\Delta X_t = [I - B(L)L]^{-1} A^{-1} D\varepsilon_t = \theta(L)\varepsilon_t .$$

However, the response of *x*, rather than the change in x, is the main concern for economists. Therefore we need a little more manipulation for equation (2-12). By assuming that all the elements of ε at time *0* and earlier are equal to zero, the impulse responses can be generated recursively as follows

$$x_1 = x_0 + \theta_0 \varepsilon_1$$

$$x_2 = x_1 + \theta_0\varepsilon_2 + \theta_1\varepsilon_1 .$$

Inserting the expression for x_1, we get

$$x_2 = x_0 + \theta_0\varepsilon_2 + (\theta_0 + \theta_1)\varepsilon_1 .$$

Repeating the operation for all x to x_t yields the following

$$x_t = x_0 + \theta_0\varepsilon_1 + (\theta_0 + \theta_1)\varepsilon_{t-1} + ... + (\sum_{j=0}^{t-j}\theta_j)\varepsilon_1 .$$

The result is equivalently as follows

(2-13) $$x_t = x_0 + \Gamma(L)\varepsilon_t = x_0 + \sum_{i=0}^{t-1}\Gamma_i\varepsilon_{t-i} ,$$

where $\Gamma_i = \sum_{j=0}^{i}\theta_j$.

The response of x_{t+i} to ε_t is Γ_i. Since ΔX is assumed stationary, the θ_j matrix goes to zero as j gets large. This implies that Γ_i converges to the sum of coefficients in $\theta(L)$. Restrictions on this sum of coefficients are used to identify long-run structural VAR models. The variance decompositions for this model replace θ in equation (2-11) by Γ.

Impulse responses and variance decompositions are derived using parameters from an explicit structural economic model. If their dynamic patterns are consistent with the structural model used for identification, this would provide evid`ence in support of the theoretical model. Otherwise, the theory is invalid or the empirical structural approach is somehow misspecified.

2.3 Traditional Choleski versus Structural Approaches

As Stock and Watson (2001, p.102) indicate, VARs come in three varieties: reduced form, recursive, and structural. A reduced form VAR expresses each variable as a linear function of its own past values of all other variables of interest and a serially uncorrelated error term. Thus, the reduced form can be estimated by ordinary least squares regression. The error terms in these regressions are the surprise movements in the variables after taking its past values into account. If the different variables are correlated with each other—as they typically are in the macroeconomic applications—then the error terms in the reduced form model will also be correlated across equations.

A recursive VAR constructs the error terms in each regression to be uncorrelated with the error in the preceding equations. This is done by judiciously including some contemporaneous values as regressors. For example, in a three-variable VAR ordered as (1) inflation, (2) the unemployment rate, and (3) the interest rate, the first equation for a recursive VAR takes inflation as the dependent variable, and the regressors are lagged values of all three variables. In the second equation, the unemployment rate is the dependent variable, and the regressors are lags of all three variables plus the current value of the inflation rate. The interest rate is the dependent variable in the third equation, and the regressors are lags of all three variables plus the current values of the inflation rate and the unemployment rate. The ordinary least squares estimation for each equation produces residuals that are uncorrelated across equations. This algorithm is equivalent to estimating the reduced form, then computing the Choleski factorization of the reduced form VAR covariance matrix, as proved by Lütkepohl (1993, chapter 2). The Choleski approach employs the reduced form VAR residuals to identify the unique lower triangular matrix *R*, solving the following equation into orthogonal shocks

$$R\Sigma_z R' = \Sigma_v .$$

This statistical decomposition depends on the sequence in which variables are ordered in *Z*. The residual covariance matrix from a VAR ordered by inflation rate, unemployment rate and interest rate yields a Choleski decomposition that is algebraically equivalent to estimating the following three equations by ordinary least squares

$$z_t^{\pi} = v_t^{\pi}$$

$$z_t^{u} = r_1 z_t^{\pi} + v_t^{f}$$

$$z_t^{r} = r_2 z_t^{\pi} + r_3 z_t^{u} + v_t^{p} .$$

The Choleski decomposition yields a system in which $e_t = Rv_t$. Each shock, v_t, is uncorrelated with the other shocks, by construction. This system implies the contemporaneous restriction that the first variable responds to its own exogenous shock, the second variable responds to the first variable plus an exogenous shock to the second variable, and so on.

The Choleski approach has been criticized by Cooley and Leroy (1985). First, if the Choleski decomposition is in fact atheoretical, then the estimated shocks are not structural and will generally be linear combinations of the structural disturbances, $v_t = R^{-1}e_t = R^{-1}A^{-1}u_t$. In this case, standard VAR analysis is difficult to interpret because the impulse responses and variance decompositions for the Choleski shocks will be complicated functions of the dynamic effects of all the structural disturbances. The second attack claims that the Choleski ordering can be interpreted as a recursive contemporaneous structural model. However, most economic theories do not imply recursive contemporaneous systems. A particular Choleski factorization of the covariance matrix for the results is appropriate only when theory predicts a contemporaneous recursive economic structure.

A structural VAR uses economic theory to sort out the contemporaneous links among the variables. Structural VARs require identifying assumptions that allow correlations to be interpreted causally. These identifying assumptions can involve the entire VAR, so that all the causal links are identified. This produces instrumental variables that permit the contemporaneous links to be estimated using instrumental variables regression. The number of potential structural VARs that fit the data is limited only by the ingenuity of the researcher.

CHAPTER 3

LITERATURE REVIEW OF TAIWAN'S ECONOMY

The historical review of Taiwan's economy here is to set the step for application of the VAR to Taiwan. In this chapter, we review the economic development of Taiwan from "Dissertations of Taiwan Economic development" to find the possible shocks that impact Taiwan the most. These papers are from Kuo (1994), Soon (1994), Yu (1994), and many others etc.[1] Their deliberate observations and research give a remarkable record of Taiwan's economic growth.

3.1 Government's Economic Planning

The strong economic growth of Taiwan since 1950 is well recognized. From 1950 to 1991, its annual average real GNP was 6.4%. In 1991, nominal GNP reached $NT 1802.7 billion. According to Soon (1994), Taiwan's government started its four-year economic planning in 1953. The economic plan can be divided into four stages.

(1) Stage 1-- Controlled imports: from 1953 to 1960, Taiwan's economy developed its own industries by imposing restrictions on import goods and financial services, things such as high import duties and foreign currency exchange controls.

(2) Stage 2-- Export expansion period: by encouraging investment for export oriented industries, from 1961 to 1972, the foreign market-oriented industries expanded

[1] These outstanding economists' research papers of Taiwan are collected into a book. Its title is "Dissertations of Taiwan Economic Development."

dramatically, contributing to tremendous trade surplus, as well as pushing Taiwan's economy into a high growth level stage.

(3) Stage 3-- Import control and industrial restructuring: in this stage from 1973 to 1981, the government developed capital-intense industries such as semi-products, material refining and so on. Export-oriented industries still were the main objects supported by government's fiscal policies.

(4) Stage 4-- Comprehensively and deliberately open economic policies: since 1991, the government commenced to remove financial and market restrictions, and to establish freely competitive markets by selling the government-run companies to the public.

3.2 Oil Supply Shocks

Despite the outstanding economic growth rate in the past 40 years, however, Taiwan's economy experienced two dramatic oil-supply shocks (Kuo, 1994). In 1974, Taiwan's economy was severely depressed by the first oil-supply shock in 1973. The price level rose by 22.9% in 1973 and 40.6% in 1974 and the real economic growth rate decreased from 12.8% in 1973 to 1.1% in 1974 and 4.2% in 1975. The second oil-supply shock began in 1979. The price level was inflated by 13.8% in 1979 and 21.5% in 1980. The second shocks decreased the real economic growth rate from 13.9% in 1978 to 8.1% in 1979 and 6.6% in 1980 respectively (Table 3-1).

According to Table 3-2, in general, money supply is highly related to the price level with time lags of one or two years, especially during the oil supply shock periods. In 1972 the money supply increased by 37.9%, while in 1973 the price level was up by 22.9%. The money supply increased by 49.3% in 1973, and the price level increased by

40.6% in 1974. In addition, the money supply increased by 34.1% in 1978, pushing the price level up again by 13.8% in 1979, and 21.5% in 1980 respectively. In order to deal with the severe impact of the oil supply shock on the economy, Taiwan's government increased fiscal spending to revive the depressed economy but adopted tighter monetary policy after its inflation. The contracting monetary policy brought down the price level; however, economic growth was also depressed during the following two years.

Kuo indicated how the money supply is increased. She divided the sources of increased money supply into three categories: (1) the net change of foreign assets (NFA), (2) the net change of government fiscal balance and (3) the net change of excess money supply of banks (Table 3-3). The three categories are determined by international trade balance, change of government saving, and the change of the banks' loan and investment minus the change of their savings, transferable CD and net values.

Kuo also discovered that in 1972,1973, 1978, and 1979: (1) the increase of net foreign assets (NFA) is the major source of the increased money supply; (2) the change of government debt or surplus decreases the money supply rather than increases the money supply; (3) the money supply was not highly related with the increase of bank loans except in 1973. In 1973 the high growth rate of bank loans and NFAs contributed about 50% of the money supply increase. The tremendous increase of NFAs also was the main source of money supply growth in 1978.

As shown in table 3-3, the increase of NFAs is the primary factor for the growth of money supply. Kuo divided the increase of NFAs into two parts--trade balance and basic balance. From Table 3-4, we can find that Taiwan had trade surplus and positive basic balance from 1970 to 1981 except 1974 and 1975. During the years of extraordinary increases in the money supply, the trade surplus accounted for the important portion of the growth of GDP. That is, 8.2% in 1972, 6.8% in 1973, 5.4% in 1977, and 8.3% in 1978. When the Central Bank tried to prevent the exchange rate from appreciation in order to keep the trade surplus, it has to sell domestic currency in the foreign exchange market. Therefore, the continued trade surplus caused the steady increase of money supply. The increased money supply not only pushes up the price level but also caused the capital outflow of the domestic saving to the other countries.

The tremendous increase of trade surplus, based on open economy theory, can be primarily attributed to the real exchange rate. Kuo (1994) used effective exchange rate (EER) and purchasing power parity (PPP) to evaluate the factor, which impacted the trade balance in the 1970s and 1980s.

(1) Purchasing power parity (PPP)

PPP index is the comparison of the domestic price index relative to the price index of the other countries. Kuo chose the year of balanced trade and balanced basic account as the base year with index equal to 100. If the PPP index is greater than 100, it means the growth rate of the PPP index of other countries is higher than the rate of domestic price level and if less than 100, lower price level otherwise. From Table 3-5, we can find out that the inflation rates of other countries are higher than Taiwan's during the 1970s except 1974. In 1970,1971, 1972, and 1978, Taiwan's inflation rate is relatively stable compared to the rate of other countries.

(2) Effective exchange rate (EER) index

EER index is the weighted average of exchange rate in terms of domestic currency relative to the other countries (i.e., the trade partners). An EER index higher than 100 means that domestic currency value increased in comparison to the currency values of Taiwan's trade partners. The opposite means the inverse relationship. From Table 3-5, for the balanced trade and basic account as indicated by Kuo, we can choose 1980 as the base year and the PPP and EER indexes are 100.

(3) The real EER

Taiwan's competitiveness of export goods can be evaluated by the real EER. That is, the EER index divided by the PPP index. A real EER higher than 100 indicates less competitive export goods and more competitive otherwise. Table 3-5 indicates that the real EER is lower than 100 except in 1974 either in terms of export value or total trade value. This indicates that Taiwan's export industries had experienced their prosperity during 1970s. It also should be noticed that the real EER in 1972 and 1978 is relatively low, this stimulated the tremendous increase of trade surplus, causing the increase of net foreign assets and the expansion of money supply.

Before the two oil supply shocks, Taiwan's economic situation was in a stable growth stage with low inflation. The oil supply shocks sparked inflation and inflation expectations. Generally speaking, the high inflation rate during those years can be attributed to two main reasons: (1) the oil supply shocks caused the price increase of material and intermediate goods, which resulted in the overall price surge; and (2) the cumulative trade surplus before the oil shocks caused the tremendous increase of money supply. Without the excess money supply, the two oil shocks could not cause the overall price surge in such a short period. However, the overall price level could still be increased in the following seasons as the high oil price continued. In addition, in Taiwan the control or prohibition of import goods as well as capital outflow to overseas might have exaggerated the severe economic situation at that time.

3.3 Fiscal and Monetary Policy

In order to deal with the impact of the two oil-supply shocks, according to Kuo (1994), Taiwan's government adopted the following fiscal and monetary policies.

(1) High interest rate

With the high inflation rate since 1973, the government was obligated to increasing the interest rate on April and June 1973. The mortgage rate raised by 2 percentage points to 13.25% and discount rate raised by 1.75 percentage points to 11.75% annually. Despite all the adjustment of the interest rate, the anticipated inflation did not subside. The inflation rate still went up by 4% in a month. Saving accounts and CDs continued decreasing from October 1973. People did not like to hold money as stored value. It was on January 1974 that the inflation rate went up at 12.9% per month; therefore on January 27, 1974, the government again raised interest rates, as shown in Table 3-6.

It is worth noticing that this interest rate policy had the following features: (1) the annual interest rates of CDs were raised by 3.43 percentage points on average, the annual interest rates for loans were also increased by 3.5 percentage points (2) the adjusted short-term (under nine months) saving interest rates (i.e., Three-Month CD for 11.5%, Six-Month CD for 12.5%, and Nine-Month CD for 13%) were higher than the former long-term (longer than one year) saving interest rates (i.e., One-Year CD for 11%, Two-Year CD for 11.5%, and Three-Year CD for 12%); (3) after the adjustment, one-year CD saving interest rates were 15%, higher than the interest rates for loans, 13.75% annually; and (4) the government bonds, the saving accounts and CDs issued before can be applied to the new interest policy. The high interest rate policy successfully eased the inflation pressure. In Table 3-7, we can find that the amount of savings accounts and CDs started their increase since February 1974. The money flowed back into the banking system for the high interest rate policy.

(2) Once-at-all oil price markup

In fall 1973, international oil prices went up dramatically. The international price level marched up with the strong anticipation of inflation overall the world. In the beginning, the government-owned monopoly petroleum company, China Petroleum, was able to absorb the markup cost of crude oil prices. However the anticipated inflation made economic agents start to increase inventory for inflation speculation. Also, the oversupplied money in 1973 made the situation even worse. This caused the inflation rate to reach its peak on January 1974.

In order to deal with the inflation pressure, the petroleum company was obligated to raise the price of oil and its byproducts by an average of 88.4% and electric utility price by 78.7% on January 27, 1974. Although oil price increased, which increased costs and price levels, the price mark-up stopped people's speculation on necessary goods and materials. The growth rate of the price index was curbed and started to decrease on the following months (see Table 3-7). The inflation caused by the first oil supply shock was successfully controlled.

(3) Tax reduction

The purpose of tax reduction in 1974 was to reduce the cost of products and to facilitate the recovery of the economy. The tax reduction brought about a NT$460 million decrease in personal income taxes but an increase of value-added taxes about NT$100 million. The net income tax decreased by NT$360 million in 1974. In the same year, the estimated import tax was also decreased by about NT$6.74 billion, accounting for about a 25% import tax in 1974. Table 3-8 shows the comparison of the estimated amount of tax reduction in 1974. The total amount of tax income estimated was decreased by about NT$11.1 billion, which is about 12.9% of annul tax income of the year, or accounting for 2.1% of GNP in 1974. The tax reduction effect was remarkable.

(4) Expanded government spending

The Big-Ten infrastructure construction projects[2] were under way in 1973 and were finished in 1979 as planned. The ten major public construction projects included six items of transportation constructions, three government-owned companies of investment in heavy industries like China Steel Corporation etc and one nuclear power electric plant. These investments more or less helped recover the depressed economy in 1974. These investments accounted for 4.5% of total amount of investment in 1973 and 1974 respectively, and 20% in 1975 and 1976. This expanded public spending increased domestic aggregate demand, and economic growth (Table 3-9).

[2] The Big-Ten infrastructure plans are the biggest ten government's projects in public facilities in order to revive the depressed economy. The ten constructions commenced in 1973 and accomplished in 1979.

3.4 The Fiscal and Monetary Policies for Second Oil-supply Shock

The impact of the second oil-supply shock was less severe than the first one. Taiwan's government did not take radical policies. These policies included cost-based oil price adjustment and flexible exchange rates and interest rates. These government policies proceeded as follows:

(1) Price of oil and the other related goods

The government's price policy of oil and the related goods was to reflect the cost of crude oil. From 1979 to 1981, the price of oil and electricity was adjusted up in order to reflect the cost of crude oil and to improve the efficiency of energy use.

(2) Exchange rate

In order to have the exchange rate reflect the market situation, on February 1979, the Central Bank of Taiwan switched the fixed exchange rate regime to a flexible exchange rate regime without interference unless necessary. The real effective exchange rate (REER) was one of the major indicators used to gauge the trend of exchange value of the New Taiwan dollar.

(3) Interest rate

The central bank set the highest and lowest rates of interest. However, the interest rate policy during the second oil-supply shock was to have the money market decide the interest rate. In order to let the interest rate fluctuate freely and closely with the money market situation, from November 1980 to December 1982, the central bank adjusted the interest rates ten times.

(4) Fiscal policy

After the second oil supply shock, the government did not increase government spending for the reason that in one way the increased spending could exaggerate the situation of money supply and on the other hand fiscal deficit appeared at the first time in 1980.

Although the second oil supply shock had less severe but wider and longer impacts on Taiwan's economy than the first one, the impact subsided under the free market mechanism. Since August 1982 the inflation rate decreased, and the economy recovered although Taiwan's government intervened less in the markets. Comparing the two experiences of oil supply shocks, we can observe that government control over those markets might smooth the fluctuation of the economy, yet it also may worsen the economic situation. As many macroeconomic theories postulate, money supply, fiscal spending and tax reduction, as well as the oil price have contemporaneous and lagged impact on the economy. The fluctuation of these four factors produce shocks on the economy and drive the economy away from the long-run equilibrium.

3.5 Economic Model of Taiwan's Economy

Every country has its own economic features. These features must be considered while setting up the macroeconomic model of a country. In this issue, Yu (1994) proposed his own observation of Taiwan's features as follows.

(1) Manufacturing for export plays a key role in economic growth

Given its lack of natural resources, Taiwan has to develop its economy by importing raw materials, machinery, as well as elements or parts to manufacture goods in order to export these finished goods for economic development. Since 1960, Japanese and U.S. industries exported their technology and original manufacturing equipment to Taiwan. Taiwan acted as the manufacturing center in the worldwide economy. This strategy stimulated the Island's economy and spurred economic growth. In the late 1980s, the New Taiwan dollar appreciated dramatically relative to the US dollar. This reduced exports to the United States. In 1986, exports to the U.S. accounted for 48% of Taiwan's total exports. But in 1990, the amount decreased to 28%. However, exports to Southeast Asia, China, and Western Europe increased dramatically to offset the decrease.

(2) Government Owned corporations

The size of government owned corporations is tremendous in Taiwan. It includes electric power, banks, public utilities, steel, petroleum, etc. The prices of these products are controlled by government and highly related to economic growth, especially domestic oil price policy. The prices of these products not only influence domestic living standards but also affect the manufacturing cost of industries. The profit of government-owned companies plays a important role for fiscal spending.

(3) Small and medium OEM (original equipment manufacturing) enterprises as the major reasons for economic growth

According to government statistics, about 60% of exports on average are from small and medium OEM enterprises in Taiwan. Instead, big companies primarily manufacture semi-products for domestic markets. Since the small and medium enterprises are price takers in competitive world markets, the vigorous economic environment gave these small and medium enterprises to compete with each other.

Those who survived at that time have grown up to become important suppliers for their international partners like IBM, HP, and so on.

(4) Rapid change of economic structure

As a small and open economy, Taiwan's export industries have evolved every ten to twenty years. Before 1960, agricultural products were the primary goods for export. In 1970s, textile products became the most important industry for Taiwan's economy. Since 1980, electric products have been the major industries for Taiwan's economic growth. Under such rapid environmental change, Taiwan's small and medium enterprises were flexible enough to survive in the competitive world markets.

To identify the sources of macroeconomic fluctuations, it is important to know what kind of variables will affect those influential economic agents who determine the movement of aggregate supply and aggregate demand disturbances. Many economic scholars in Taiwan have researched the sources of factors that impact Taiwan's economy. Chan and Lan (1996) compared the factors of money supply, international oil price, GDP of Taiwan, GDP of U.S. and price indexes between Taiwan and the U.S., based on controlled floating exchange rate and fixed exchange rate regimes. They found that the floating exchange rate regime is better than the fixed exchange rate regime in protecting Taiwan's economy from those shocks. As one can see, the international oil price is an important source of business cycle fluctuations since Taiwan lacks this important natural resource. In addition, many economic theories and research have indicated that government intervention is an important measure to avoid the economy deviating from long-run equilibrium. Policy variables such as monetary and fiscal policy, as well as exchange rate policy, are among the primary factors that impact the behavior of most economic agents and in turn the fluctuation of AS and AD. In general, monetary disturbances are primary sources of economic fluctuations in the short run. Monetary authority tends to increase money supply to stimulate the economy during recession and decrease the supply to cool down an overheating economy. Many economists argued that the increase of money supply would stimulate the economy through money illusion and lower interest rates in the short run. In the long run, however, economic agents would rearrange their assets against the expected long-run inflation. This kind of capital arrangement continues until the economy reaches its long-run equilibrium.

Moreover, money supply may be affected by fiscal policies, exchange rate policies and the price level. Increased fiscal deficits may decrease money supply if government borrows money from private saving, and this may have a crowding out effect on the economy; however, if the deficits are monetized (financed by printing money), the money supply may be increased. In addition, fiscal policy is always in accordance with the short-term economic cycle, especially when severe recession occurs. In such a situation, government tends to increase spending to revive the depressed economy. But with lagged economic information, government's fiscal spending might not be under way at the right time.

When the Central Bank avoids the exchange rate deviating from the target zone, monetary policy might be affected. For example, if the Central Bank wants to keep its currency from appreciation due to tremendous trade surplus, the authority needs to sell its currency at the foreign exchange rate market. This will cause the increase of domestic money supply. On the other hand, monetary supply always adjusts to accommodate the transaction needs in the long run.

CHAPTER 4

KARRAS MODEL--THE CASE OF U.S. REVISITED

4.1 Introduction to Karras Model

Karras (1993) constructs a just-identifying structural VAR model for the U.S. using six macroeconomic variables. These are oil price, GNP price deflator, money supply, real GNP, government deficit, and nominal exchange rate. As in Karras's setting, these variables are used to examine the structural shocks and dynamic innovations for each variable in the model. The original feasible structural VAR operation for Karras's model is set up as follows: lacking natural crude oil, the economy (output) tends to fluctuate with the variation of the international oil price, which is categorized as an oil shock. On the other hand, the other important sources of structural shocks, according to macroeconomic economic theory, are termed as non-oil shocks, including fiscal policy, monetary policy, (non-oil) aggregate supply, (non-fiscal, non-monetary) aggregate demand and exchange rate, respectively. Aggregate demand innovations include shocks to private spending (consumption and investment), and aggregate supply shocks include technological and labor market disturbances. These structural VAR equations are restricted so as to identify the dynamic innovations and structural variance based on a generally accepted macroeconomic model.

The structural VAR (SVAR) employs a two-step approach. The first step is to employ the VAR technique. One can obtain the covariance matrix $\sum_z$ from the residuals of the estimated reduced-form model (i.e., Eq.4-4). Since the covariance matrix contains the mixed correlation of the six sources of shocks, Karras converted the covariance matrix into independent structural shocks by a system of just-identifying contemporaneous equations according to macroeconomic theory. The specification of the contemporaneous structural equations is extremely important to give the interpretation of the dynamic innovation for each variable. The underlying assumption is that the economy's behavior is primarily captured by the system of structural equations, which transforms the VAR's covariance matrices into systematically uncorrelated structural shocks $\sum_u$.[1] The original structural model is specified as follows

(4-1) $$A\begin{bmatrix} O_t \\ Y_t \end{bmatrix} = \sum_{i=1}^{k}\begin{bmatrix} 0 & 0' \\ c_i & C_i \end{bmatrix}\begin{bmatrix} O_{t-i} \\ Y_{t-i} \end{bmatrix} + D\begin{bmatrix} u_t^o \\ u_t^y \end{bmatrix},$$

where $Y = (f, p, m, y, e)'$, and $u = (u^o, u^y)' = (u^o, u^f, u^s, u^m, u^d, u^e)'$ is the vector of the six structural disturbances: oil price, fiscal deficit , money supply, aggregate demand, aggregate supply, and exchange rate. A is the matrix for the contemporaneous equations, and k is the proper lags on each variable. The structural shocks are assumed to be uncorrelated and D is an identity matrix. Therefore, $\sum_u = E(u_t u_s')$ is assumed to be diagonal if $s = t$, and equal to zero otherwise. The oil price is assumed independent of the other variables. The inclusion of this variable allows an evaluation of the effect of oil price fluctuations on variables such as aggregate supply and aggregate demand. The structural systems of equation (4-1) may be normalized by setting diagonal elements of matrix A as unity. That is

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[1] However, any misspecification of the economic theoretic restrictions on contemporaneous structural equations may result in the improper inference about the structural shocks and their dynamic innovation.

(4-2) $$A\begin{bmatrix} O_t \\ Y_t \end{bmatrix} = \sum_{i=1}^{k} \begin{bmatrix} 0 & 0' \\ c_i & C_i \end{bmatrix} \begin{bmatrix} O_{t-i} \\ Y_{t-i} \end{bmatrix} + \begin{bmatrix} u_t^o \\ u_t^y \end{bmatrix}.$$

The estimated reduced-form model is rewritten as

(4-3) $$\begin{bmatrix} O_t \\ Y_t \end{bmatrix} = \sum_{i=1}^{k} A^{-1} \begin{bmatrix} 0 & 0' \\ c_i & C_i \end{bmatrix} \begin{bmatrix} O_{t-i} \\ Y_{t-i} \end{bmatrix} + A^{-1} \begin{bmatrix} u_t^o \\ u_t^y \end{bmatrix},$$

or it can be rewritten as

(4-4) $$X_t = \sum_{i=1}^{k} B_i X_{t-i} + z_t,$$

where

$$X_t = \begin{bmatrix} O_t \\ Y_t \end{bmatrix}$$

$$B_i = A^{-1} C_i$$

$$z_t = A^{-1} u_t$$

$$E(z_t z_t') = \sum_z,$$

and $z = (o, f, p, m, y, e)$ are the estimated residuals. Equation (4-4) is a standard 6-variable VAR with the only exception that the growth rate of oil price is assumed to be white noise. Thus, all the right hand side variables of the sixth equation, including the lags of oil price itself, have coefficients constrained to zero. The procedure of SVAR is used to obtain the structural shocks *(u)* from the reduced form residuals *(z)*. Equation 4-4 indicates that

(4-5) $$E(z_t z_t') = A^{-1} \sum_u A'^{-1}.$$

Equation (4-5) indicates that an estimate of the orthogonalized contemporaneous system of structural equations (elements of matrices, *A*) can be used to identify the diagonalized structural shocks *u*. Therefore, we can restrict the 15 upper off-diagonal elements of matrix A to be zero and have a maximum of 15 nonzero parameters *A* (lower off-diagonal elements) in equation (4-5). Thus, the matrix *A* is an orthogonalized matrix with all *1s* in the diagonal elements and 15 nonzero parameters as the lower triangle elements. A plausible set of contemporaneous restrictions of the linear model set up by Karras is

$$o = u_t^o$$

$$f = f(y)$$

$$y^s = y^s(p, o)$$

$$m = m(f, y, p)$$

$$y^d = y^d(p, o, f, m)$$

$$e = e(o, f, m, y, p).$$

This model implies that the oil price, o, does not depend on any other variable. The fiscal variable, f, may depend on y because tax revenues are likely to be procyclical and government spending countercyclical. The aggregate supply, y^s, tends to increase with price deflator, p, and decrease with oil price, o. The money supply may be affected by both real and nominal factors: real GNP, y, fiscal policy, f, and GNP deflator, p. The aggregate demand is also captured by both real and nominal factors (o, f, m, p). And the fluctuation of the nominal exchange rate, e, is allowed to be affected by all the other five variables (o, f, m, p, y). Thus the explicit model is as follows

(4-6) $\quad z_t^o = u_t^o$

(4-7) $z_t^f = a_1 z_t^y + u_t^f$

(4-8) $z_t^{ys} = a_2 z_t^o + a_3 z_t^p + u_t^{ys}$

(4-9) $z_t^m = a_4 z_t^f + a_5 z_t^p + a_6 z_t^y + u_t^m$

(4-10) $z_t^{yd} = a_7 z_t^o + a_8 z_t^f + a_9 z_t^p + a_{10} z_t^m + u_t^{yd}$

(4-11) $z_t^{ex} = a_{11} z_t^o + a_{12} z_t^f + a_{13} z_t^p + a_{14} z_t^m + a_{15} z_t^y + u_t^{ex}$.

The specification of the contemporaneous model is important to convert the VAR residuals into structural shocks. The identification of structural VAR disturbances requires the contemporaneous coefficient matrix be restricted to 15 (or under 15) nonzero coefficients for the just identified model.[2] Many alternative models have been tried so as to find the best estimates. The model selection criteria are based on: (1) most accepted macroeconomic theories, for example, aggregate demand should be negatively related to the GNP deflator, and aggregate supply positively related; (2) the value of R-square statistics; (3) an *F-test* on the selected model; and (4) the significance level of coefficients for all competing variables in the model.

According to the structural VAR, identification of the contemporaneous equations is used to convert the correlated VAR residuals into structural innovations of which is demonstrated in equation (4-12)

$$A\Sigma_z A' = \Sigma_u .$$

[2] If more than 15 zero coefficients restricted in the contemporaneous coefficient matrix, the Structural VAR model is over identified. If less than 15 zero coefficients restricted, the Structural VAR model cannot be identified.

Or in detailed expression:

$$\begin{matrix} O & D & P & M & Y & E \end{matrix} \qquad \begin{matrix} O & D & P & M & Y & E \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & a_1 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & 0 \\ a_7 & a_8 & a_9 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix} \begin{bmatrix} \sigma_o^2 & \sigma_{od} & \sigma_{op} & \sigma_{om} & \sigma_{oy} & \sigma_{oe} \\ \sigma_{do} & \sigma_d^2 & \sigma_{dp} & \sigma_{dm} & \sigma_{dy} & \sigma_{de} \\ \sigma_{po} & \sigma_{pd} & \sigma_p^2 & \sigma_{pm} & \sigma_{py} & \sigma_{pe} \\ \sigma_{mo} & \sigma_{md} & \sigma_{mp} & \sigma_m^2 & \sigma_{my} & \sigma_{me} \\ \sigma_{yo} & \sigma_{yd} & \sigma_{yp} & \sigma_{ym} & \sigma_y^2 & \sigma_{ye} \\ \sigma_{eo} & \sigma_{ed} & \sigma_{ep} & \sigma_{em} & \sigma_{ey} & \sigma_e^2 \end{bmatrix}$$

$$\begin{matrix} O & D & P & M & Y & E \end{matrix} \qquad \begin{matrix} O & D & P & M & Y & E \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & a_1 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & 0 \\ a_7 & a_8 & a_9 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix}' = \begin{bmatrix} u_o^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & u_f^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & u_p^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & u_m^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & u_y^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & u_e^2 \end{bmatrix}.$$

Therefore, equation (4-12) can be used to identify structural shocks ($u^o, u^f, u^{ys}, u^m, u^{yd}, u^e$). With all the structural shocks recovered, we can proceed to calculate impulse response functions and variance decomposition functions as shown in chapter 2. Notice that the VAR procedure is normalized on price level. Thus, the cumulated IRFs of the price level, money aggregate, RGNP, and exchange rate show their relationship to the price (inflation) shock.

4.2 Empirical Results from Karras

The estimation period for the U.S. employed by Karras (1993) is from 1973:1 to 1989:4. The data are seasonally adjusted. In his model, Y is the logarithm of real GNP and f is the logarithm of the real government deficit. The seasonally adjusted federal government surplus is negative for the whole period, and thus the logarithm of the deficit is well defined. *P* is the logarithm of the GNP price deflator. *E* denotes the logarithm of the SDR per U.S. dollar. *O* is the logarithm of the oil price deflated by *P*. *M2* is the logarithm of monetary aggregates.

Karras employed his restricted model (*a1=0, a9+a10=0,* and include the exchange rate in the money equation) to recover the six structural shocks, which are used to generate the impulse response and variance decomposition functions. Table 4-1 shows that the variance decompositions for the six variables of interest, and in parentheses, standard deviations obtained by Monte Carlo simulations. The numbers reported indicate the percentage of the forecast error in each variable that can be attributed to each of the structural innovations at different horizons. The percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead). Also notice that the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks for convenience.

For the variance decompositions (Karras's results) non-oil aggregate supply innovations have the greatest impact on output at all horizons whereas oil shocks gain importance in the medium and long run. Demand-side shocks also contribute to output, and monetary innovations have the greatest impact among them.

Regarding inflation, money shocks dominate at all horizons, especially in the long run. Aggregate supply disturbances have effects that decrease over time. With respect to the exchange rate, relatively high degree of persistence is exhibited. Even in the five-year horizon the exchange rate is 48% explained by its own innovation. Monetary shocks appear to be more responsible for exchange rate changes than fiscal shocks at all horizons.

For the impulse response functions, aggregate supply (oil and non-oil) shocks are again seen to be the dominant source of output response. Consistent with theory, their effects on output are permanent. On the contrary, the response of output to demand-side shocks eventually die out. The response to monetary innovations has the expected hump-shaped effect on output with a peak after 3 quarters. After that, their effect steadily diminishes. On prices, money supply shocks also have the expected effects becoming dominant in the long run. Oil shocks lead to a permanent higher price level, but only higher money growth produces a permanently higher inflation rate. Fiscal innovations appear to be neither strongly expansionary nor inflationary.

Regarding the exchange rate, monetary shocks appear to be the major source of fluctuations and in the directions implied by theory, positive monetary shocks depreciate the dollar. On the contrary, the impact of fiscal innovations on the exchange rate appears to contradict the prediction of the Mundell-Fleming model: positive fiscal innovations (increases in the budget deficit) tend to also depreciate the dollar.

Karras also shows that the three major contributors to the variability of output are oil, aggregate supply, and monetary shocks. Fiscal, other aggregate demand and exchange rate shocks have negligible contributions. Money is very important in the short run whereas supply shocks have long-term importance. The "snow-flake" theory (that no two recessions are alike) seems to be supported: the 1975 recovery is due to oil and aggregate supply; the 1980 downturn is a result of monetary policy with some contribution from supply; negative contributions from oil, money, and supply produce the severe 1981-82 recession.

Oil, money and supply shocks are also the primary forces behind the fluctuations of prices. Overall, monetary innovations are responsible for price level movements, both on a quarter-to-quarter basis and over the long run.

Finally, the results also indicate that money disturbances have a lot of influence from quarter to quarter, but they are not responsible for the persistent appreciation of the dollar in the early 1980s or its dramatic depreciation after 1985. Those "swings" in the value of the U.S. currency are mostly explained by the exchange rate innovations themselves, which means that the puzzle of what drove the dollar in that period remains largely unresolved. The conventional view holds that higher budget deficits appreciate the currency because they lead to higher interest rates. But this view is not supported by the results of Karrras's finding. Karras (1993) contended that if budget deficits have no effect on the interest rate (for example, because Ricardian Equivalence holds) the exchange rate will not appreciate, and if a fraction of the deficit is financed by issuing money, higher inflationary expectations might lead to a depreciation.

4.3 The Case of U.S. Revisited

The estimation period for the U.S. is extended from 1973:1 to 2001:2. All variables are seasonally adjusted. In his model, Y is the logarithm of real GNP. f is the ratio of the logarithm of the real government deficit to government debt subtracted from one. We use this manipulation because some of the seasonally adjusted budget deficits are still positive; in this case the log level of the fiscal variable is not well defined. P is the logarithm of the GNP price deflator. *E* denotes the logarithm of the SDR per U.S. dollar. *O* is the logarithm of the oil price deflated by *P*. *M2* is the logarithm of monetary aggregates. Data for *Y*, *M2* and *P* are obtained from the Federal Reserve Bank of St. Louis. Oil price is acquired from the International Monetary Fund's (IMF) *International Financial Statistics*.

The VAR procedure requires the data series of interest to be stationary. It is crucial for the estimation that the data series are stationary. The Dickey-Fuller's Z and t test as well as Dickey-Fuller's joint test of unit root are used to examine the stationary tests of all the variables. Table 4-2 presents the results of Augumented Dickey-Fuller tests on the log levels of the variables. The results find that the first difference of *O, f, E, P, Y, M2,* and *M2/P* are stationary.

Based on Karras's results, a VAR was estimated in first differences of the log levels on O, *f, P, M2, Y and E* with oil price as a random variable. Several alternative specifications for the lag structure and determinants were tested. The VAR model with a constant and four lags are adopted.

Once the VAR is estimated and the reduced-form residuals are obtained, the contemporaneous equations are estimated in order to recover the structural shocks. The following estimation of the simultaneous equations employs two-stage least squares (2SLS), as employed in Karras's restricted model to recover the six structural shocks of which are used to generate the impulse response and variance decomposition functions.

1. Oil price is restricted as a random variable.
2. Deficit is also restricted as random variable so that $z_t^f = u_t^f$.

3. Use o_t and u_t^f as instrument variables for equation (4-8) to calculate

$$u_t^s = \hat{z}_t^y - (a_2 o_t + a_3 \hat{z}_t^p).$$

4. Use o_t, u_t^f and u_t^s as instrument variables for equation (4-10) to calculate

$$u_t^d = z_t^y - \hat{z}_t^y = z_t^y - (a_8 o_t + a_9 \hat{z}_t^f + a_{10} (\hat{z}_t^m - \hat{z}_t^p)).$$

5. Use o_t, u_t^f, u_t^s, and u_t^d as instrument variables for equation (4-9) to run regression to calculate $u_t^m = z_t^m - \hat{z}_t^m = z_t^m - (a_4 \hat{z}_t^f + a_5 \hat{z}_t^p + a_6 \hat{z}_t^y + a_7 \hat{z}_t^{ex})$.

6. Use o_t, u_t^f, u_t^s, u_t^m and u_t^d as instrument variables for equation (4-11) to calculate

$$u_t^e = z_t^e - \hat{z}_t^e = z_t^e - (a_{11} o_t + a_{12} \hat{z}_t^f + a_{13} \hat{z}_t^p + a_{14} \hat{z}_t^m + a_{15} \hat{z}_t^y).$$

The estimated parameters show the quantified relationship among the dependent variables in the selected structural equations. Table 4-3 presents the estimated contemporaneous model presented in equations 4-6 to 4-11 for the *M2* money aggregate. Many of the estimated coefficients are significant such as oil price and the GNP deflator in the aggregate supply equation; GNP deflator and RGNP variables in the money equation; and M2 money in the aggregate demand equation.

In this restricted model, most of the signs are consistent with macroeconomic theory. Aggregate supply has a positive relationship with respect to the increase of price level and negative response to oil price, and the coefficients are significant. Aggregate demand has a positive response to the increase of the money aggregate at a highly significant level. It also has an inverse relationship with the GNP deflator, as macroeconomic theory postulates. In the money supply equation, the nominal M2 money tends to increase in response to the rising GDP deflator as well as real GNP; in addition, money supply also increases when fiscal expense increases. In the exchange rate equation, it shows that the dollar tends to appreciate when oil price, real GNP, and GNP deflator increase and depreciate in response to the decrease of *M2* money and fiscal spending. The empirical findings show that the signs of coefficients follow the most-accepted macroeconomic theories.

Once the coefficients of matrix A are estimated, we can identify the structural shocks and the dynamic innovation of the variables of interest through variance decomposition and impulse response functions. As long as the system's covariance matrix is diagonal or all structural equations are just identified, the relative efficiency of each alternative will be the same. The identification of the contemporaneous equations is used to convert the correlated VAR residuals into structural innovations which is demonstrated in equation (4-12):

$$A\Sigma_z A' = \Sigma_u .$$

In detailed expression it is:

$$\begin{array}{cc} \begin{matrix} O & D & P & M & Y & E \end{matrix} & \begin{matrix} O & D & P & M & Y & E \end{matrix} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & a_7 \\ a_8 & a_9 & 0 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix} & \begin{bmatrix} \sigma_o^2 & \sigma_{od} & \sigma_{op} & \sigma_{om} & \sigma_{oy} & \sigma_{oe} \\ \sigma_{do} & \sigma_d^2 & \sigma_{dp} & \sigma_{dm} & \sigma_{dy} & \sigma_{de} \\ \sigma_{po} & \sigma_{pd} & \sigma_p^2 & \sigma_{pm} & \sigma_{py} & \sigma_{pe} \\ \sigma_{mo} & \sigma_{md} & \sigma_{mp} & \sigma_m^2 & \sigma_{my} & \sigma_{me} \\ \sigma_{yo} & \sigma_{yd} & \sigma_{yp} & \sigma_{ym} & \sigma_y^2 & \sigma_{ye} \\ \sigma_{eo} & \sigma_{ed} & \sigma_{ep} & \sigma_{em} & \sigma_{ey} & \sigma_e^2 \end{bmatrix} \end{array}$$

$$\begin{array}{ccc} \begin{matrix} O & D & P & M & Y & E \end{matrix} & & \begin{matrix} O & D & P & M & Y & E \end{matrix} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & a_7 \\ a_8 & a_9 & 0 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix}' & = & \begin{bmatrix} u_o^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & u_f^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & u_p^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & u_m^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & u_y^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & u_e^2 \end{bmatrix} . \end{array}$$

Equation (4-12) can be used to identify structural shocks ($u^o, u^f, u^{ys}, u^m, u^{yd}, u^e$). With all the structural shocks recovered, we can proceed to calculate impulse response functions and variance decomposition functions as shown in chapter 2. Notice that in the VAR procedure, the VAR procedure is normalized on price level. Thus, the accumulated IRFs of the price level, M2, RGNP, and exchange rate show their relationship to the price (aggregate supply) shock. The following empirical findings will be based on the restricted Karras model as above with the *M2* aggregate.

4.4 Empirical Results and Discussion

The variance decompositions and the impulse response functions quantify the importance of the structural disturbances for the variables of interest on average over the whole period of sampling. Significant economic events during the period may have profound impacts on the economic variables of interest. Table 4-4 presents the variance decompositions and mean squared errors for the six variables of interest. The numbers reported indicate the percentage of the forecasted errors in each variable that can be attributed to each of the structural innovations at different horizons. As in Karras (1993), the percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead). Also notice that for convenience the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks.

Oil price by construction is only affected by its own innovations. It is modeled as a random walk with no feedback from the rest of the other variables. Fiscal variation is dominated by its own variation in all horizons. As to price level variation, as macroeconomic theory postulated, aggregate supply shocks are highly significant in the short term, gradually decay from about 53-17% variation in the long run; M2 money is getting more important in the long run, accounting for about 34-54% variation of inflation; while aggregate demand and exchange rate shocks are getting significant in the long-term. For monetary variation, aggregate demand dominates the variation of M2 money during the horizons, from 87 to 68 percent.

For the variation of aggregate demand (output), it shows that the monetary effect accounts for 58-54% fraction of the variation during the horizons whereas aggregate supply also plays an important role for the variation at all horizons, from 27-24%. It is interesting to find that the monetary effect plays an important role for the U.S. demand variation in all horizons although it is not shown that aggregate demand has a dominant effect for the output variation in the short run; the exchange rate is explained around 80% by its own innovations in the five-year horizon; the others are found less significant for the variation.

Impulse response functions present the responses of variables over time to innovations of each structural disturbance. The accumulated impulse response functions of output, the price level, and the exchange rate to one standard deviation of the six shocks are shown in Figures 4-1 to 4-3. Figures 4-1 (a) to 4-1 (f) demonstrate accumulated IRFs of output (real GNP) to the six shocks. Figure 4-1 (a) shows that the shocks of oil price decrease real GNP to -0.19 percentage points and the effect reduces to -0.12 percentage points in the medium and long run. Figure 4-1 (b) shows that fiscal innovations have small and positive effects on output in the short run and the effects are

0.2 percentage points in the medium and long run. Figure 4-1 (c) illustrates that price (inflation) innovations decrease output, from -0.3 percentage points in the short run to -0.6 percentage points in the medium and long run. The responses of output to monetary innovations also are positive and decay over time as one might expect (Figure 4-1 (d)). The effects increase to 0.72 percentage points at third quarter, and decrease to 0.5 percentage points in the long run. Figure 4-1 (e) shows that aggregate demand shocks have only a short-term effect on output, as economic theory postulates. The effects increase to 0.2 percentage points at the first quarter, and decrease to -0.2 percentage points in the long run. Figure 4-1 (f) shows that the exchange rate shocks have positive effects on the output and the effects increase to 0.3 percentage points in the long run.

Figures 4-2 (a) to 4-2 (f) demonstrate the price level response with respect to the six shocks. Figure 4-2 (a) shows that the shocks of oil price increase the price level over time and the effect grows in the long run. The effects increase the price level from 0.02 percentage points in the short run to 0.18 percentage points in the long run. Figure 4-2 (b) shows that fiscal shocks have positive effects on the price level in the first quarter. The effects drop to -0.1 percentage points in the medium run and -0.06 percentage points in the long run. This indicates that fiscal shocks have only mild impact on the price level. Price (inflation) shocks increase the price level over time (Figure 4-2 (c)); the price level increases from 0.15 percentage points in the first quarter to 0.35 percentage points in the medium and long run. Figure 4-2 (d) shows that the responses of price level to monetary innovations also increase over time as one might expect. The price level increases from 0.1 percentage points in the first quarter to 1.4 percentage points in the long run. Figure 4-2 (e) shows that aggregate demand shocks have positive effects on the price level in the short and medium run, as economic theory postulated, but in the long run the price level becomes negative. The price level reached 0.15 percentage points at the sixth quarter, and decreased to -0.35 percentage points in the long run. Figure 4-2 (f) shows that the exchange rate shocks have negative effects on price level and the effects reach -0.6 percentage points in the long run.

Figures 4-3 (a) to 4-3 (f) exhibit the accumulative IRFs of the exchange rate to the six shocks. Figure 4-3 (a) shows that the shocks of oil price appreciate the exchange rate by 0.9 percentage points in the medium and long run. Figure 4-3 (b) shows that fiscal shocks have negative effects on the exchange rate over time and the effects are from -0.35 to -0.7 percentage points during the time horizon. Figure 4-3 (c) shows that price (inflation) shocks increase the exchange rate by 0.2 percentage points at the first quarter; the effects reach -0.2 percentage points at the fourth quarter, and increase to 0.3 percentage points after the tenth quarter. Figure 4-3 (d) shows that the responses of the exchange rate to monetary innovations are -0.1 percentage points at the first quarter, increase to 0.17 percentage points during the second quarter, decay to -0.05 percentage points at the ninth quarter, and increase to 0.4 percentage points in the long run. Figure 4-3 (e) shows that aggregate demand shocks have positive effects on the exchange rate, as economic theory postulated. The effects increase to 0.3 percentage points at the first quarter, decrease to 0.1 percentage points at the third quarter, and increase to 0.8 percentage points in the long run. Figure 4-3 (f) presents that the exchange rate shocks have positive effects on the exchange rate and the effects reach 0.32 percentage points at the fifth quarter.

In summary, in the accumulated IRFs of output, we find that oil and price shocks decrease output; fiscal and monetary shocks increase output, as economic theory postulates. Demand shocks have temporary effects on output, as one might expect. In the long run, the effects become negative; this could happen if there is a fiscal budget constraint during the time horizon. Surprisingly, exchange rate shocks do not decrease output during the time horizon. Monetary, and price (i.e., aggregate supply) shocks are among the most important sources of output fluctuations (0.6 percentage points compared to other shocks at 0.2 percentage points on average). Not surprisingly, the result shows that the U.S. economy (output) during the sample period is not driven by aggregate demand and fiscal innovations, the demand side disturbances in a broad definition. Thus, this finding is in favor of the notion that monetary and technical innovations are mainly the sources of the output fluctuations.

For the price level, oil, monetary and price (inflation) shocks increase the price level, while aggregate demand has only short run effects on the price level as one might expect. Money shocks are important sources of the change of inflation in the long run, and the effects are increasing over time, as macroeconomic theory postulates. The price level decreases in response to the fiscal and exchange rate shocks over all time horizons. This finding supports the view that the effect of the appreciation of the U.S. dollar may decrease the price of domestic goods. Since the U.S. has experienced a tremendous trade deficit over the last three decades, strong U.S. currency causes relatively lower prices of imported goods to domestic goods, which may decrease the domestic price level because the relative price of import goods is lower. In this situation, the cost of import companies decreases, and the profit increases. This benefits the economy in the long run.

For the exchange rate, oil, price, monetary and aggregate demand shocks tend to appreciate the U.S. currency in the long run, with only a slight effects on the exchange rate in the short run. Moreover, the impact of fiscal innovations on the exchange rate appears to depreciate the U.S. currency over the time horizon. This finding is against the popular notion of the Mundell-Flemming model, which proposes that increases in the budget deficit tend to appreciate the exchange rate; the conventional view holds because higher budget deficits lead to higher interest rates, and then appreciate the exchange rate. However, if budget deficits have no effect on interest rates (i.e., Ricardian Equivalence holds) or if a fraction of the deficit is to be monetized, as Karras indicated (1993), higher inflationary expectations might lead to depreciation. Moreover, the exchange rate depreciates in response to price innovations in the short run; this finding supports the notion that the price (inflation) shocks tends to depreciate the exchange rate.

4.5 Summary and Contrast

Karras (1993) estimated the period from 1973:1 to 1989:4 for the U.S. economy. He employs the restricted contemporaneous model to recover the six structural shocks of which are used to generate the impulse response and variance decomposition functions. We estimate the U.S. economy by imposing the same restrictions to recover the same six structural shocks during the period from 1973:1 to 2001:2. Despite most of the impulse response functions (IRFs) and forecasted error variance decompositions (FEVDs) for both models being similar, some significant differences do exist as follows.

For the variance decompositions, Karras finds fiscal variation is explained by its own innovations; the same result is found even when the sample period is extended to

2001:2. In Karras's findings, price variation in the short run is explained primarily by monetary, aggregate supply and aggregate demand disturbances. Aggregate supply and aggregate demand effect on price level decay over the time horizons, whereas the monetary effect is increasing in the medium and long run. In our findings, aggregate supply and money innovations are the dominant sources of price variation; their effects over the time horizons are the same as in Karras.

In the monetary variations, our finding shows that only aggregate demand disturbances play a primary role, 87%-68% variation over all horizons. In Karras's finding, monetary variation is explained by primarily demand innovations, followed by monetary and oil innovations. Aggregate supply explains the major fraction of output innovations in Karras's results. In our results, money supply innovations are also found as the major explanation in output variation, and aggregate supply is the second important source of output variation during the sample periods. As to the exchange rate, both models have the same conclusion that exchange rate variations are from its own disturbances. This result indicates none of the other five structural shocks can explain the fluctuation of exchange rate. It indicates that exchange rate innovations remain unidentified in our model. In other words, there exist unidentified variables in explaining the exchange rate fluctuations other than the five variables in this model.

In the accumulated impulse response functions, both results indicate that the responses of impulses of each variable to the six shocks respectively are as expected, except the extent of significant levels of each variable in the accumulated IRFs are different. For example, in the price level, both Karras's and our findings indicate monetary disturbances are the most important sources for the inflation. In the accumulated IRFs of output, aggregate supply shocks and monetary shocks have the more significant effects on output fluctuations. For the exchange rate, both models indicate exchange rate is highly volatile to its own disturbances.

CHAPTER 5

THE CASE OF TAIWAN

For the past fifty years, Taiwan has experienced tremendous economic growth with no recessions. Being an independent and small island, international trade is extremely important for Taiwan in that it accounts for a major part of Taiwan's economic growth. The economic identity is characterized as a small, open economy, but controlled by the ruling government through petroleum price controls, monetary policy, fiscal policy, exchange rate policy, as well as import and capital mobility barriers. Thus, it is worth evaluating the sources of macroeconomic fluctuations that impact Taiwan's economic growth. Based on the macroeconomic characteristics, we use the six variables of Karras's model (1993) to set up a structural VAR model to identify the sources of shocks that impact the economy of Taiwan.

5.1 Data and Implementation

The estimation period for Taiwan is from 1981:1 to 2000:4. In this model, Y is the logarithm of real GNP. f is the ratio of the logarithm of the real government deficit to government debt subtracted from one. We use this manipulation because some of the seasonally adjusted budget deficits are still positive; in this case the log level of the fiscal variable is not well defined. P is the logarithm of the GNP price deflator. Data for Y and P are obtained from the Directorate General of Budgets, Account & Statistics, Executive Yuan. E denotes the logarithm of the nominal exchange rate – the SDRs per unit of New Taiwan dollar. O is the logarithm of the oil price deflated by P. Oil prices are acquired from the International Monetary Fund (IMF) in International Financial Statistics. The logarithm of two different monetary aggregates will be tried for *M: M1B, and M2*, which are derived from the Economic Research Center of the Central Bank of Taiwan.

The VAR procedure requires the data series of interest to be stationary. It is crucial for the estimation that the data series be stationary with the correct number of differences. The Dickey-Fuller's Z- and t-test as well as Dickey-Fuller's joint test of unit root are used to examine stationarity of all variables. Table 5-1 presents the results of Augumented Dickey-Fuller's tests on the log levels of the variables. The results find that the first difference of *O, f, E, P, Y, M2,* and *M2/P* are stationary.

Based on Karras, a VAR was estimated in first differences of the log levels on *O, f, P, M2, Y and E,* with oil price restricted as a random variable. Several alternative specifications for the lag structure and variable determinants were tested. Based on the tests of the lag structure and equation determinants, the VAR model with a constant and four lags was adopted.

After the VAR is estimated and the reduced-form residuals are obtained, estimation of contemporaneous equations as in 4-6 to 4-11 occurs to recover the structural shocks. The same criteria are used as in the U.S. case to select the appropriate model for Taiwan. The estimated coefficients are shown in Table 5-2. Unfortunately, both estimated models used in Karras (1993) show that some of the signs of the estimated coefficients would be unexpected. For example, in the aggregate supply equation, aggregate supply does not positively respond to price level, no matter what variables are included in the equation. In addition, we also find that the signs of the coefficients in the contemporaneous equations are inconsistent for different time horizon. The estimated coefficients on the contemporaneous equation reflect the economic situation over the time period. The signs of these estimated coefficients might be changed for different sampling periods. These signs might be inconsistent with the economic theories contemporaneously over different time horizons, which might undermine the structural VAR decomposition.

Once the coefficients of matrix A are estimated, we can identify the structural shocks and their dynamic innovation of the variables of interest through variance decomposition and impulse response functions. As long as the system's covariance matrix is diagonal or all structural equations are just identified, the relative efficiency of each alternative will be the same. The identified contemporaneous equations are used to convert the correlated VAR residuals into structural innovations, which are demonstrated as in equation (4-12)

$$A\Sigma_z A' = \Sigma_u .$$

This equation can be used to identify structural shocks ($u^o, u^f, u^{ys}, u^m, u^{yd}, u^e$). With all the structural shocks recovered, we can proceed to calculate impulse response functions and variance decomposition functions. Notice that in the VAR procedure, it is normalized on the price level. Thus, the accumulated IRFs of the price level, *M2*, real GNP, and exchange rate show their relationship to the price (inflation) shock.

5.2 Empirical Results and Discussion

The variance decomposition and the impulse response functions quantify the importance of the structural disturbances for the variables of interest on average over the whole period of sampling observations. Significant economic events during the period may have a profound impact on the economic variables of interest. It is important to notice what Taiwan's economy had experienced from 1981 to 2000. For example, four important events amid the sampling period had an impact on Taiwan's economy. First, the second world oil crisis since 1979 impacts the economy severely. The crisis decreased real GNP with higher price level for the following two years. Second, the dramatic depreciation of U.S. currency relative to Asian currencies since 1989 impacts the export-oriented Taiwan economy. At the same time, foreign investment funds flowed into Asia, which caused domestic real estate prices to soar. The money prospered Taiwan's real estate industry and the stock market. Third, the Asian financial crisis (capital flee) since 1998 impacted heavily the economy of Asian countries (Thailand, Malaysia, Indonesia, Korea, as well as Japan etc.). The event caused the dramatic exchange rate depreciation among almost every Asian country. Also, capital investment from Taiwan to Mainland China has been increasing since 1998; it caused price decreases in real estate, decreases in domestic consumption and investment, and rises of unemployment rate as well. Fortunately, unlike the other Asian countries, Taiwan's real GNP was impacted less by the crisis due to the prosperity of the information technology (IT) industry from 1998 to 2000. The growth of the IT industry brought about the prosperity to Taiwan's electronic industries. On the other hand, government's ability to control the policy variables such as domestic petroleum price[3], fiscal expense, money supply, and exchange rate may impact the estimation of contemporaneous equations. All

[3] In Taiwan, Chinese Petroleum Corporation, a public-run company, controlled the petroleum price. It is a monopoly market.

these impacts will be quantified on average into the six identified structural disturbances for the following variance decompositions and impulse response functions.

The empirical findings that follow are based on the *M2* aggregate for the restricted and original Karras models as well as the Choleski model. It is interesting to find that the two Karras models show similar results in the impulse response functions except for the monetary shocks. In the monetary shocks, the restricted Karras model shows more consistent results from a macroeconomic point of view. In comparing the Karras and Choleski models, from a macroeconomic point of view, Karras's models show more appropriate results both in the accumulated IRFs and the forecast error variance decompositions.

5.2.1 The Restricted Karras Model

The restricted Karras model (with restriction on $a1=0$, $a9+a10=0$, and including exchange rate in the money equation, as shown in Table 5-2 (A)) is used to identify the structural shocks and impulse response functions (IRF) as well as forecast error variance decompositions (FEVD). The following estimation of the simultaneous equations employs two-stage least squares (2SLS), as employed in the restricted Karras model, to recover the six structural shocks of which are used to generate the impulse response and variance decomposition functions.

(1) Oil price is restricted as a random variable.

(2) Deficit is also restricted as random variable so that $z_t^f = u_t^f$.

(3) Use o_t and u_t^f as instrument variables for equation (4-8) to calculate

$$u_t^s = \hat{z}_t^y - (a_2 o_t + a_3 \hat{z}_t^p).$$

(4) Use o_t, u_t^f and u_t^s as instrument variables for equation (4-10) to calculate

$$u_t^d = z_t^y - \hat{z}_t^y = z_t^y - (a_8 o_t + a_9 \hat{z}_t^f + a_{10}(\hat{z}_t^m - \hat{z}_t^p)).$$

(5) Use o_t, u_t^f, u_t^s and u_t^d as instrument variables for equation (4-9) to run regression to calculate $u_t^m = z_t^m - \hat{z}_t^m = z_t^m - (a_4 \hat{z}_t^f + a_5 \hat{z}_t^p + a_6 \hat{z}_t^y + a_7 \hat{z}_t^{ex})$.

(6) Use o_t, u_t^f, u_t^s, u_t^m and u_t^d as instrument variables for equation (4-11) to calculate

$$u_t^e = z_t^e - \hat{z}_t^e = z_t^e - (a_{11} o_t + a_{12} \hat{z}_t^f + a_{13} \hat{z}_t^p + a_{14} \hat{z}_t^m + a_{15} \hat{z}_t^y).$$

The estimated parameters show the quantified relationships among the dependent variables in the selected structural equations. Table 5-3 presents the percentage of the forecasted errors in each variable that can be attributed to each of the six structural innovations at different horizons. The numbers reported indicate the percentage of the forecasted errors in each variable that can be attributed to each of the six structural innovations at different horizons. As in Karras's article (1993), the percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead). Also notice that the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks for convenience.

Oil prices by construction are only affected by oil innovations. This is because the international price of oil is not affected by the other variables in Taiwan's macroeconomic model. Therefore, it is modeled as a random walk with no feedback from the rest of the variables. Deficit variation is explained by its own shocks over the time horizons. On the price level, international oil price innovations account for about 28-37% variation of inflation over all horizons. Aggregate supply shocks are more significant, about 61-51% variation in the time horizons. In the monetary variation, monetary, exchange rate, oil, aggregate demand shocks dominate the variation at all horizons, especially in the short run; whereas oil shocks are significant in the medium, and long run. For the output variation, aggregate demand and exchange rate shocks account for the majority of variation, especially in the short run. It also shows that aggregate demand has the dominant effect in the short run.

For the exchange rate, in the short run it is explained 73% by money innovations, decreasing to 55% in the longer run. Deficit shocks account for the exchange rate innovations around 20-17% during the 5-year time periods and oil price has little effect on exchange rate in the short-run, but it accounts for 12% in the medium- and long-run.

Impulse response functions present the responses of variables over time to innovations of each structural disturbance. The accumulated impulse response functions of the output, the price level, and the exchange rate to one standard deviation of the six shocks are shown in Figures 5-1 to 5-3. Figures 5-1 (a) to 5-1 (f) demonstrate accumulated IRFs of output (real GNP) to the six shocks. Figure 5-1 (a) shows that the shocks of oil price increase output by about 0.2 percentage points in the short run and decrease output by -0.4 percentage points in the long run. Figure 5-1 (b) shows that fiscal innovations have small and cyclic effects on output in the short- and medium- run and the effects reach 0.3 percentage points in the long run. Figure 5-1 (c) presents that price (inflation) innovations do not decrease output until the third quarter, by -0.2 percentage points; the effects decay in the long run. The responses of output to monetary innovations also are positive over time except in the first quarter; the responses increase to 0.5 percentage points in the long run (Figure 5-1 (d)). Figure 5-1 (e) shows that aggregate demand shocks have positive effects on output, as economic theory postulates. The effects are 0.7 percentage points at the first quarter, and increase to 1.4 percentage points in the long run. Figure 5-1 (f) presents that the exchange rate shocks decrease the output (-0.4 percentage points at the first quarter). In the long run, the effects increase output to 0.3 percentage points.

Figures 5-2 (a) to 5-2 (f) demonstrate the price level with respect to the six shocks. Figure 5-2 (a) shows that the shocks of oil price decrease the price level (at -0.4 percentage points) and the effects decay to -0.3 percentage points in the long run. Figure 5-2 (b) shows that fiscal shocks have positive effects on the price level over time. The effects increase to 0.35 percentage points in the long run. Price (inflation) shocks increase the price level over time (Figure 5-2 (c)); the effects increase the price level from 0.6 percentage points at the first quarter to 1.2 percentage points in the long run. Figure 5-2 (d) shows that the responses of the price level to monetary innovations also increase over time as one might expect. The effects increase from 0.05 percentage points at the first quarter to 0.4 percentage points in the long run. Figure 5-2 (e) shows that aggregate demand shocks on the price level are negative over time. The effects reach -0.25 percentage points at the sixth quarter, and decay to -0.1 percentage points in the long run. Figure 5-2 (f) shows that the exchange rate shocks have a mixture of positive and negative effects on the price level in the short- and medium-run. The effects reach 0.15 percentage points in the long run.

Figures 5-3 (a) to 5-3 (f) exhibit the accumulative IRFs of the exchange rate to the six shocks. Figure 5-3 (a) shows that the shocks of oil price appreciate the exchange rate over time. The effects reach 1.4 percentage points at the fourth quarter and decay to 0.2 percentage points in the long run. Figure 5-3 (b) shows that fiscal shocks have positive effects on the exchange rate over time and the effects are from 1 to 2 percentage points during the time horizon. Figure 5-3 (c) demonstrates that price (inflation) shocks depreciate the exchange rate by 0.48 percentage points at the first quarter. The effects reach -0.9 percentage points at the sixth quarter, and decay to -0.7 percentage points in the long run. Figure 5-3 (d) illustrates that the responses of the exchange rate to monetary innovations are negative over time. The effects reach -2.4 percentage points at the first quarter, and rebound to -0.15 percentage points in the medium- and long-run. Figure 5-3 (e) shows that aggregate demand shocks have positive effects on the exchange rate, as economic theory postulated. The effects increase to 0.15 percentage points at the fifth quarter, and increase to 0.18 percentage points in the long run. Figure 5-3 (f) presents that exchange rate shocks have positive effects on itself over time and the effects increase to 0.12 percentage points in the long run.

In summary, in the accumulated IRFs of output, the shocks of oil price decrease output in the long run. Fiscal and monetary innovations increase output in the long run. Price (inflation) innovations have cyclic effects on output and the effects decay over time. Also notice that the VAR procedure is normalized on the GNP deflator, thus the IRFs show that the decrease of output is related with the increase in price level. Aggregate demand shocks have long-term effects on output and are the most important sources of output fluctuations (from 0.7 to 1.4 percentage points over time compared to other shocks at 0.5 percentage points on average for the other shocks). This finding supports the notion that an export-oriented economy might experience higher output fluctuation due to the demand shocks from its trader partners. The responses of output to exchange rate shocks are positive in the medium- and long- run. Output has the expected responses to the monetary and demand shocks but the result contradicts the economic notion that monetary and demand innovations should have only short run effects on output. However, in an economy with rapid growth rate like Taiwan, people have rational expectation for the rapid growth; money and demand shocks may have long run effect in the accumulated IRFs. It is important to notice that Taiwan's economy has been growing (no recession) during the past four decades except in 2001.

In the accumulated IRFs of the price level, oil shocks do not increase the price level over the time periods, as one might expect. However, if the oil shocks are only temporary, and people do not have the inflation expectation. In this situation, temporary oil shocks might not increase the price level. Fiscal and monetary shocks have positive effects on the price level over time, as macroeconomic theory postulates. Fiscal and monetary shocks are not the important sources of the inflation in the short run, while their effects are increasing over time. Price (inflation) shocks have the most significant effects on the price level among the six shocks, especially in the long run (1.2 percentage points). Aggregate demand shocks have mild and negative effects, and the effects decay in the long run. Exchange rate shocks have a mixture of positive and negative effects on the price level in the short run, and the effects are positive in the long run.

In the accumulative IRFs of the exchange rate, oil shocks appreciate the exchange rate over time. Against the case of the U.S., the impact of fiscal innovations on the exchange rate appears to appreciate Taiwan's currency over time. As macroeconomic theory postulates, this finding supports the popular notion of the Mundell-Flemming model, which proposes that increases in the budget deficit tend to appreciate the exchange rate; the conventional view holds because higher budget deficits lead to higher interest rates, and then appreciate the exchange rate. Price shocks tend to depreciate the Taiwan currency in the time horizons, especially in the medium- and long- run. Monetary shocks significantly depreciate Taiwan's currency during the time horizons, especially in the short run. Aggregate demand and exchange rate shocks appreciate Taiwan's currency during the time horizon.

It is interesting to notice that fiscal shocks have significant impact on the exchange rate over time. Price (negative supply) shocks impact the output only in the short run, and surprisingly the effect on the output is not significant as one might expect. Monetary shocks have mild effects on the price level and the output, but have more significant impact on the exchange rate. Demand shocks seem to have higher effects on the output and the exchange rate than one might expect; this finding supports the view that for an export-oriented economy, demand shocks from its trade partners have a higher impact on the output. Exchange shocks have only mild, short-run effects on output but have higher effects on the exchange rate itself in the long run. It is also interesting to notice that the exchange rate is more sensitive to the major economic shocks such as aggregate demand, fiscal and monetary shocks for the case of Taiwan.

5.2.2 The Original (Unrestricted) Karras Decomposition

Estimation of the simultaneous equations employs two-stage least squares (2SLS) based on the original Karras decomposition, also shown in table 5-2 (B), proceeds as follows.

(1) Oil price is restricted as a random variable.

(2) Use o_t and u_t^f as instrument variables for equation (4-8) to calculate $u_t^f = z_t^f - a_1\hat{z}_t^y$.

(3) Use o_t and u_t^f as instrument variables for equation (4-8) to calculate

$u_t^s = z_t^y - (a_2 o_t + a_3 \hat{z}_t^p)$.

(4) Use o_t, u_t^f and u_t^s as instrument variables for equation (4-9) to run regression to calculate $u_t^m = z_t^m - \hat{z}_t^m = z_t^m - (a_4\hat{z}_t^f + a_5\hat{z}_t^p + a_6\hat{z}_t^y)$.

(5) Use o_t, u_t^f, u_t^s and u_t^m as instrument variables for equation (4-10) to calculate

$u_t^d = z_t^y - \hat{z}_t^y = z_t^y - (a_7 o_t + a_8\hat{z}_t^f + a_9\hat{z}_t^p + a_{10}\hat{z}_t^m)$.

(6) Use o_t, u_t^f, u_t^s, u_t^m and u_t^d as instrument variables for equation (4-11) to calculate

$u_t^e = z_t^e - \hat{z}_t^e = z_t^e - (a_{11} o_t + a_{12}\hat{z}_t^f + a_{13}\hat{z}_t^p + a_{14}\hat{z}_t^m + a_{15}\hat{z}_t^y)$.

Table 5-4 present the forecasted error variance decompositions and mean squared errors for the six variables of interest. The numbers reported indicate the percentage of the forecasted errors in each variable that can be attributed to each of the six structural innovations at different horizons. As in Karras's article (1993), the percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead).

Also notice that the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks for convenience.

Oil prices by construction are only affected by oil innovations. Deficit variation is explained by money and its own shocks. It is unusual to find that money shocks are the primary sources for deficit variation unless that the deficit is financed by money printing. This finding might indicate that deficit is monetized (financed by printing money). On the price level, international oil price innovations account for about 24-33% variation in inflation for all horizons. Price (Aggregate supply) shocks are more significant, about 66-55% variation for all horizons. Money shocks are not significant for price variations. In the monetary variation, aggregate demand shocks dominate the variation at all horizons, especially in the short run (65%), whereas oil shocks are also significant in the medium, and long run. For the output variation, deficit shocks account for the majority of variation, followed by aggregate supply and monetary shocks. It is not shown that aggregate demand has a dominant effect in the short run.

For the exchange rate, in the short run it is explained 65% by its own innovations, decreasing to 47% in the long run. Monetary and aggregate demand shocks account for the exchange rate innovations around 10-18% respectively during the 5-year time periods, and oil price has little effect on the exchange rate in the short-run, but it accounts for 15% in the medium- and long-run.

Compared to the restricted Karras model in which exchange rate variations are explained primarily by monetary shocks (73%-55%), the variation of exchange rate is explained by its own shocks at 65%. The reason for this is that in the restricted Karras model, the restrictions (a1=0, a9+a10=0 and include exchange rate in the money equation) give different estimates in the contemporaneous equations, which have influences on the forecasted error variance decomposition functions.

Impulse response functions present the responses of variables over time to innovations of each structural disturbance. The accumulated impulse response functions of the output, the price level, and the exchange rate to one standard deviation of the six shocks are shown in Figures 5-4 to 5-6. Figures 5-4 (a) to 5-4 (f) demonstrate accumulated IRFs of output (real GNP) to the six shocks. Figure 5-4 (a) shows that the shocks of oil price increase output by 0.2 percentage points from the first to the third quarters and the effects reach -0.8 percentage points in the long run. Figure 5-4 (b) shows that fiscal innovations have negative effects on output over time. The effects decrease the output (-0.7 percentage points at first quarter) and decay to -0.3 percentage points in the long run. Figure 5-4 (c) shows that price (inflation) innovations do not decrease output until the third quarter; the effects decrease output by -0.3 percentage points at the seventh quarter and decay in the long run. The responses of the output to monetary innovations also are positive over time; the responses increase to 1.4 percentage points in the long run (Figure 5-4 (d)). Figure 5-4 (e) shows that aggregate demand shocks have positive effects on output in the short run, as economic theory postulated; the effects reach 0.2 percentage points at the first quarter, but drop to -0.6 percentage points in the long run. Figure 5-4 (f) presents that the exchange rate shocks decrease output to -0.4 percentage points at the sixth quarter. In the long run, the effects decay to -0.3 percentage points.

Figures 5-5 (a) to 5-5 (f) demonstrate the price level response with respect to the six shocks. Figure 5-5 (a) shows that the shocks of oil price decrease the price level (at -0.4 percentage points on average) in the short and long run and the effects are -0.3

percentage points on average in the medium run. This result is not as one might expect. However, if the oil price shocks are just temporary, economic agents may not have inflation expectation. The price level might not increase. Figure 5-5 (b) shows that fiscal shocks have positive effects on the price level over time. The effects increase to 0.38 percentage points in the long run. Price (inflation) shocks increase the price level over time (Figure 5-5 (c)). The effects increase the price level from 0.6 percentage points at the first quarter to 1.2 percentage points in the long run. Figure 5-5 (d) presents that monetary innovations do not increase the price level until the eleventh quarter; however, the price level increases to 0.2 percentage points in the long run. Figure 5-5 (e) shows that aggregate demand shocks increase the price level in the short- and medium- run. The effects reach 0.1 percentage points at the sixth quarter, and decay to -0.04 percentage points in the long run. Figure 5-5 (f) shows that the exchange rate shocks have negative effects on the price level over time. The effects reach -0.25 percentage points in the long run.

Figures 5-6 (a) to 5-6 (f) exhibit the accumulative IRFs of the exchange rate to the six shocks. Figure 5-6 (a) shows that the shocks of oil price appreciate the exchange rate over time. The effects reach 1.7 percentage points at the fourth quarter and decay to zero in the long run. Figure 5-6 (b) shows that fiscal shocks have positive and mild effects on the exchange rate over time; the effects are from 0.05 to 0.45 percentage points during the time horizon. Figure 5-6 (c) demonstrates that price (inflation) shocks depreciate the exchange rate by 0.2 percentage points at the first quarter; the effects reach 0.2 percentage points at the third quarter, and decrease to -0.45 percentage points in the long run. Figure 5-6 (d) illustrates that the responses of the exchange rate to monetary innovations are positive over time. The effects reach 0.6 percentage points at the first quarter, and increase to 3 percentage points in the medium and long run. Figure 5-6 (e) shows that aggregate demand shocks have positive effects on the exchange rate in the short- and medium- run, as economic theory postulated. The effects increase to 1.2 percentage points at the second quarter, and drop to -0.18 percentage points in the long run. Figure 5-6 (f) shows that exchange rate shocks have positive effects on itself over time and the effects increase to 2.5 percentage points at the second quarter and decay to 1.5 percentage points in the long run.

In summary, in the accumulated IRFs of output, the shocks of oil price decrease output in the long run. Fiscal innovations decrease the output over time. Price (inflation) innovations have cyclic and negative effects on output and the effects decay over time. Also notice that the VAR procedure is normalized on the GNP deflator, thus the IRFs show that the decrease of output is related with the increase in price level. Monetary shocks have positive effects on output over time. Aggregate demand shocks have positive effects on output only in the short run. The responses of output to exchange rate shocks are negative over time.

In the accumulated IRFs of the price level, oil shocks do not increase the price level over the time periods, as one might expect. However, if the oil shocks are only temporary, and people do not have inflation expectations, then in this situation, temporary oil shocks might not increase the price level. Fiscal and monetary shocks have positive effects on the price level over time, as macroeconomic theory postulates. Fiscal and monetary shocks are not the important sources of the inflation in the short run, while their effects are increasing over time. Price (inflation) shocks have the most significant effects on the price level among the six shocks, especially in the long run (from 0.6 to 1.2 percentage points). Aggregate demand shocks have mild and positive effects on the price level in the medium run, and the effects decay in the long run. Exchange rate shocks decrease the price level over time.

In the accumulative IRFs of the exchange rate, oil shocks appreciate the exchange rate over time. Against the case of the U.S., the impact of fiscal innovations on the exchange rate appears to appreciate Taiwan's currency over time. As macroeconomic theory postulates, this finding supports the popular notion of the Mundell-Flemming model, which proposes that increases in the budget deficit tend to appreciate the exchange rate; the conventional view holds because higher budget deficits lead to higher interest rates, and appreciate the exchange rate. Price shocks tend to depreciate Taiwan's currency during the time horizons, especially in the medium and long run. Against what one might expect, monetary shocks significantly appreciate Taiwan currency during the time horizons, especially in the long run. Aggregate demand and exchange rate shocks appreciate Taiwan's currency during the time horizon.

5.2.3 The Choleski Model

For comparison, we also perform the Choleski decomposition using the same six variables as those of the Karras model. The Choleski approach employs the VAR residuals to identify the unique lower triangular matrix *R*, solving the following equation into orthogonal shocks:

$$R\Sigma_z R' = \Sigma_v,$$

where Σ_z is the residual covariance matrix from the VAR equations, and Σ_v is the identified shocks from the Choleski decomposition.

This statistical decomposition depends on the sequence in which variables are ordered in the VAR equations. The residual covariance matrix from a VAR ordered by oil price, deficit, GNP deflator, money aggregate, real GNP, and exchange rate yields a Choleski decomposition that is algebraically equivalent to estimating the following six equations by ordinary least squares:

(5-1) $$z_t^o = v_t^o$$

(5-2) $$z_t^f = r_1 z_t^o + v_t^f$$

(5-3) $$z_t^p = r_2 z_t^o + r_3 z_t^f + v_t^p$$

(5-4) $$z_t^m = r_4 z_t^o + r_5 z_t^f + r_6 z_t^p + v_t^m$$

(5-5) $$z_t^y = r_7 z_t^o + r_8 z_t^f + r_9 z_t^p + r_{10} z_t^m + v_t^y$$

(5-6) $$z_t^{ex} = r_{11} z_t^o + r_{12} z_t^f + r_{13} z_t^p + r_{14} z_t^m + r_{15} z_t^y + v_t^{ex}.$$

The Choleski decomposition yields a system in which $e_t = Rv_t$. Each shock, v_t, is uncorrelated with the other shocks by construction. This system implies the contemporaneous restriction that the first variable responds to its own exogenous shock, the second variable responds to the first variable plus an exogenous shock to the second variable, and so on.

The estimated parameters show the quantified relationship among the dependent variables in the selected structural equations. Table 5-2 (C) also shows the estimated coefficients for the Choleski model. The Choleski model estimates equations 5-1 to 5-6 for the *M2* money aggregate. Many of the estimated coefficients are statistically significant, such as oil price, deficit and GNP deflator variables in the money equation, and deficit and GNP deflator in the exchange rate equation.

In general, the Choleski model has better R-square and adjusted R-square, but this model is less persuasive in the aggregate supply and monetary equations from a theoretical point of view. For example, in the aggregate supply equation, the price level is related to oil price and deficit, rather than the real GNP; and the sign of oil price is not what we expect. And in the money equation, money supply is related to international oil price instead of real GNP. Despite this inconsistency, the Choleski estimation shows that the signs of coefficients and its R-square are better than the original Karras model for the case of Taiwan. For example, aggregate demand has a positive response to the increase of the money aggregate. It also has an inverse relationship with the GNP deflator, as macroeconomic theory postulates. In the money supply equation, nominal M2 money tends to decrease in response to the rising GDP deflator. In the exchange rate equation, it shows that Taiwan's currency tends to depreciate when oil price, money supply and GNP deflator increase, and appreciate in response to rising real GNP and fiscal spending as one might expect.

The Choleski model uses the lower diagonal matrix of contemporaneous equations to derive the IRFs and FEVDs from the VAR. Table 5-5 presents the variance decompositions for the six variables of interest. The numbers reported indicate the percentage of the forecasted errors in each variable that can be attributed to each of the six structural innovations at different horizons. The percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead). Also notice that the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks for convenience.

As in Karras's setting, oil prices by construction are only affected by oil innovations. Therefore, it is modeled as a random walk with no feedback from the rest of the variables. Deficit is explained by its own variation. On the price level, oil price innovations account for about 24-33% variation on inflation in all time horizons. Aggregate supply shocks are more significant, about 66-51% variation in all horizons. Monetary variation is dominated by aggregate demand shocks, about 64-50% during the periods; while oil price and deficit shocks are also important in the time horizon. Aggregate demand shocks also dominate all output variation at all horizons; oil shocks and aggregate supply shocks are gaining significance in the long run for real GNP; exchange rate shocks have little impact at all horizons. For the exchange rate, in the short run it is explained 65% by its own innovations, decreasing to 47% in the long run. Oil price and deficit shocks together account for the exchange rate innovations around 25-30% during the 5-year time periods. Aggregate supply, demand and monetary shocks have little effect on the exchange rate in the time horizon.

Impulse response functions present the responses of variables over time to innovations of each structural disturbance. The accumulated impulse response functions of output, the price level, and the exchange rate to one standard deviation of the six shocks are shown in Figures 5-7 to 5-9. Figures 5-7 (a) to 5-7 (f) demonstrate accumulated IRFs of output (real GNP) to the six shocks. Figure 5-7 (a) shows that the shocks of oil price increase output by about 0.2 percentage points from the first to the third quarters and the effects drop to -0.8 percentage points in the long run. Figure 5-7 (b) shows that fiscal innovations have a mixture of positive and negative effects on output in the short and medium run. The effects increase the output with 0.4 percentage points in the long run. Figure 5-7 (c) shows that price (inflation) innovations decrease output over time; the effects decrease output by -0.35 percentage points on average. The responses of output to monetary innovations also are positive over time; the responses increase to 1.4 percentage points in the long run (Figure 5-7 (d)). Figure 5-7 (e) shows that aggregate demand shocks have positive effects on output over time; the effects reach 0.8 percentage points at the first quarter, and drop to 0.6 percentage points in the long run. Figure 5-7 (f) presents that the exchange rate shocks decrease output to -0.4 percentage points at the sixth quarter. In the long run, the effects decay to -0.3 percentage points.

Figures 5-8 (a) to 5-8 (f) demonstrate the price level responses with respect to the six shocks. Figure 5-8 (a) shows that the shocks of oil price decrease the price level by -0.4 percentage points on average in the short- and long- run and the effects are -0.3 percentage points on average in the medium run. Figure 5-8 (b) shows that fiscal shocks have positive effects on the price level over time. The effects increase to 0.58 percentage points in the long run. Price (inflation) shocks increase the price level over time (Figure 5-8 (c)). The effects increase the price level from 0.6 percentage points at the first quarter to 1.2 percentage points in the long run. Figure 5-8 (d) shows that monetary innovations do not increase the price level until the eleventh quarter; however, the price level increases to 0.15 percentage points in the long run. Figure 5-8 (e) shows that aggregate demand shocks have a mixture of positive and negative effects on the price level over time. Figure 5-8 (f) shows that the exchange rate shocks have negative effects on the price level over time. The effects reach -0.25 percentage points in the long run.

Figures 5-9 (a) to 5-9 (f) exhibit the accumulative IRFs of the exchange rate to the six shocks. Figure 5-9 (a) shows that the shocks of oil price appreciate the exchange rate over time. The effects reach 1.7 percentage points at the fourth quarter and decay to zero in the long run. Figure 5-9 (b) shows that fiscal shocks have positive effects on the exchange rate over time; the effects are from 1 to 2 percentage points during the time horizon. Figure 5-9 (c) shows that price (inflation) shocks depreciate the exchange rate by -0.5 percentage points at the first quarter. The effects reach to -1.2 percentage points at the fifth quarter as well as in the long run. Figure 5-9 (d) presents that the responses of the exchange rate to monetary innovations are positive except at the first and the second quarters. The shocks depreciate the exchange rate by -0.5 percentage points at the first quarter, but appreciate the exchange rate by 2 percentage points in the medium and long run. Figure 5-9 (e) shows that aggregate demand shocks have positive effects on the exchange rate over time, as economic theory postulated. The effects increase to 1.4 percentage points at the fourth quarter, and drop to 0.8 percentage points in the long run. Figure 5-9 (f) presents that exchange rate shocks have positive effects on itself over time and the effects increase to 2.5 percentage points at the second quarter and decay to 1.5 percentage points in the long run.

In summary, in the accumulated IRFs for output, the shocks of oil price decrease output in the long run. Fiscal innovations have a mixture of positive and negative effects on output in the short- and medium- run. Price (inflation) innovations have cyclic and negative effects on output. Also notice that the VAR procedure is normalized on the

GNP deflator, thus the IRFs show that the decrease of the output is related with the increase in price level. Monetary and aggregate demand shocks have positive effects on output over time. The responses of output to exchange rate shocks are negative over time.

In the accumulated IRFs of the price level, oil shocks do not increase the price level over the time periods. However, if the oil shocks are only temporary, and people do not have the inflation expectation. In this situation, temporary oil shocks might not increase the price level. Fiscal shocks have positive effects on the price level over time, as macroeconomic theory postulates. Price (inflation) shocks have the most significant effects on the price level among the six shocks, especially in the long run (from 0.6 to 1.2 percentage points). Monetary shocks are not the important sources of the inflation in the short run, while their effects are increasing over time. Aggregate demand shocks have a mixture of positive and negative effects on the price level over time. Exchange rate shocks decrease the price level over time.

In the accumulative IRFs of the exchange rate, oil shocks appreciate the exchange rate over time. Against the case of the U.S., the impact of fiscal innovations on the exchange rate appears to appreciate Taiwan's currency over time. As macroeconomic theory postulates, this finding supports the popular notion of the Mundell-Flemming model, which proposes that increases in the budget deficit tend to appreciate the exchange rate; the conventional view holds because higher budget deficits lead to higher interest rates, and appreciate the exchange rate. Price shocks tend to depreciate Taiwan's currency in the time horizons, especially in the medium- and long- run. Against one might expect monetary shocks significantly appreciate Taiwan currency during the time horizons, especially in the long run. Aggregate demand and exchange rate shocks appreciate Taiwan's currency during the time horizon.

5.2.4 Karras Versus Choleski Model

For the restricted Karras model, it is surprising to find that the coefficients of the price and money variables in the contemporaneous exchange rate equation are rather large (i.e., -16.2 for price variable and -19.7 for money variable) for the case of Taiwan. One possible reason for this finding is that the size of the economy for Taiwan is rather small compared to the U.S. When a small economy experiences such significant shocks as those to the international oil price, the exchange rate and Asian Financial Crisis, the VAR residuals are more volatile. That is, if these highly volatile residuals were outliers in the VAR residuals, from a statistical point of view, the estimation of contemporaneous equation would reflect and convert this effect into its IRFs and forecasted error variance decompositions (FEVDs). Despite the drawbacks in the estimated parameters, however, most of the results in the restricted Karras model comply with most accepted macroeconomic theory. The comparisons for the quantified accumulated IRFs and FEVDs for the Karras and Choleski models are discussed as follows.

(1) In response to the oil shocks, macroeconomic theory postulates that this effect, if longer than one might expect, would increase the price level and decrease output. In all three models, the price levels are not increased and the output decreases mildly in the medium- and long- run. This indicates that if the oil price shocks are only temporary, in which case economic

agents have no expectation on inflation, the economy may be impacted only mildly.

(2) Macroeconomic theory postulates that fiscal innovations shift the aggregate demand curve to the right, and this has positive effects on output and prices. This is shown in the restricted Karras and Choleski models in the price level; the two models show a mixture of positive and negative effects on the output in the short run. For the unrestricted Karras model, the output is not increased by the deficit shocks. From a theoretical point of view, output might not increase if there is a crowding out effect or if there is a fiscal budget constraint during the time horizon.

(3) The Mundell-Flemming model proposes that increases in budget deficits tend to appreciate the exchange rate. We find that the fiscal innovations appear to appreciate the exchange rate for the three models.

(4) Keynesian theory proposes that inflation shocks would increase the expected inflation. This would decrease output (recessionary gap) and increase price level; with higher price level and lower output, the exchange rate tends to depreciate. This result is shown in each of the three models.

(5) According to theory, money shocks would decrease the interest rate, and output and price level would go up. The responses of the output and the price level to monetary innovations are found positive in the long run for the restricted Karras model. For Choleski and unrestricted Karras models, output is increased, but the price level has a mixture of positive and negative responses to the monetary shocks in the short- and medium- run.

(6) Economic theory postulates that aggregate demand shocks would increase output and price level only in the short run. The restricted Karras and Choleski models show that the output increases over time and the price level decreases mildly. While in the unrestricted Karras model, demand shocks have only short-run effects on output and a mixed effects on the price level.

(7) Positive nominal exchange rate shocks would decrease output because the increase of real exchange rate decrease the net export, which cause the decline in output and price level; in the Choleski and unrestricted models, the output and the price level decrease during the time horizons as the theory postulates. The restricted Karras model shows that the output and the price level decrease only in the short run. However, if the export can be expanded to the other foreign markets, the shift effect in net exports might outweigh the exchange rate shocks and thus output might not decrease in the long run.

It is also interesting to find that the two Karras models show similar results for the accumulated impulse response functions to the six shocks except in the monetary and demand shocks. In the monetary shocks, the restricted Karras model shows that the exchange rate depreciates in response to monetary shocks, as one might expect, but the unrestricted model shows the opposite. The restricted model is more consistent than the unrestricted one from a theoretical point of view. In the demand shocks, however, the restricted Karras model shows the demand shock having a long-run effect on output, while the unrestricted Karras model shows only a temporary effect on output. The unrestricted model seems to have a more persuading result for demand shocks.

Comparing the Karras and Choleski models, the Choleski model is less persuasive in the contemporaneous estimation from a theoretical point of view; for example, in the Choleski model, the aggregate supply equation shows that supply would respond to oil price and deficit rather than oil price and price level; and in the monetary equation, money supply would be affected by the international oil price rather than output, and this is a contradiction to generally accepted economic theory.

In addition, the Choleski model shows less desired results in the accumulated IRFs. For example, the Choleski model shows that money shocks also have no effect or little effect in the long run on the change of inflation. In addition, it shows monetary shocks appreciating Taiwan currency over time (except in the short run). This finding is against macroeconomic theory, which postulates that an increase in money supply would decrease the real interest rate and then depreciate the exchange rate.

5.3 The Identified Structural Shocks

The structural VAR also allows us to examine whether the identified structural shocks over time are appropriate. By the comparison of these three models in the accumulated IRFs and FEVDs, we find that the restricted Karras model is better than the other two decompositions. We also compare the structural shocks of the three estimated models with the actual fluctuations of economic variables to see whether the decomposition is appropriate or not. The identified structural shocks may help to explain the fluctuations of economic variables of interest during the sampling period (1981:1 to 2000:4). Positive shocks indicate actual figures of economic variables of interest are higher than expectation and negative shocks are otherwise lower. Figures 5-10 (a) to 5-10 (f) present the identified six structural shocks from 83:2 to 2000:4.

The international oil price reached its peak at $39 per barrel in 1981 during the second oil crisis; it decreased to $28 per barrel by 1985; then dropped to $13 in1986. The oil price was around $15 - $20 during 1987-1989. In 1990, the international oil price soared to $31 due to the Gulf war, then dropped to the $20s over the following 8 years until year 2000 in which it again reached $30 per barrel. Corresponding to the oil price fluctuations, we identified significant spikes of structural oil price shocks 1986:1 (negative), 1987:1(positive), 1988:3 (negative), 1989:1 (positive), 1990:2 (negative) and 1990:3 (positive), 1998:1 (negative) and 1999:2 (positive). The structural oil price shocks represent actual fluctuations of the international oil prices, which are higher (positive) or lower (negative) than one might expect. For fiscal policy, the deficit dramatically increased in 1989:2. The government deficit increased every year since 1990. As one might expect, the identified positive spike of the structural deficit shocks corresponds to the dramatic increase of deficit in 1989:2.

Taiwan's price level soared in the 1981-1982 period due to the second oil crisis, and remained flat during the 1986:1-1988:3 periods then soared in 1988:4-1998 except in 1997:1. The price level adjusted up in 1990:3 during the Gulf War periods due to the high oil price. In the 1993-2000 periods, the price level climbed with a spike in1996:3 and 1997:4 and decreased after the Asian Financial Crisis in 1998:2-1999:2 periods with a trough in 1998:4. These events are identified in the structural shocks

For the monetary side, generally speaking, the supply of M2 steadily increased during the sample period. Since the money supply is influenced principally by the

Central Bank, we find that most of the identified structural monetary shocks are positive from 1984:3 to 1986:2 when Taiwan's economy experienced a recession, and during Asian Financial Crisis in 1998. We also find highly volatile shocks during the Gulf War in 1991. This finding might indicate that the Central Bank tried to control the money supply over time in responding to the significant economic events in order to reach its economic goals. This finding is not captured in the impulse response functions.

For output, Taiwan's economy experienced economic growth annually in the past forty years. Taiwan's economy experienced higher economic growth rate during the 1989-1990, 1994-1995 and 1997-2000 periods. A proportion of the economic expansion in 1998-1990 is due to the depreciation of Taiwan's currency during the periods. Due to the depreciation of Taiwan's currency and the boom of the computer industry during 1996-2000, the economy was not badly harmed by the Asian Financial Crisis in 1997. The identified structural shocks correspond to the similar results as above. This finding supports the view that the flexible exchange rate regime is more helpful in protecting the export-oriented country from international shocks. The economy experienced dramatic growth in 2000:2 due to the heyday of information technology (IT) industry. The identified structural shocks show significant negative shocks in 1983:2, 1984:3,1985:4, 1986:4, 1988:2 and 1991:1-2. These shocks correspond to the fact that the economy slowed during1981-1985 and 1991 periods due to the second oil crisis in 1980 and due to the Gulf War in 1991.

For exchange rate, Taiwan's currency appreciated during 1984 then experienced significant depreciation in 1985:2-1987:1. The exchange rate appreciates dramatically during 1987:2-1994 with the peak during 1989. Taiwan's currency also depreciated due to the Gulf War in 1990 and the Asian Financial Crisis since 1997:4. Corresponding to the actual fluctuations, the identified structural shocks of exchange rate are found positive during 1983:2-1985:1 then turn down during 1985:2-1986:2. We also find negative spikes during 1989:4-1990:3 as well as in 1997:4.

CHAPTER 6

THE CASE OF JAPAN

Karras's methodology with the six variables is also employed to analyze Japan's macroeconomic fluctuations. In this model, Y is the logarithm of real GNI; f is the ratio of the logarithm of the real government deficit to government debt subtracted from one. We use this manipulation because some of the seasonally adjusted budget deficits are still positive; in this case the log level of the fiscal variable is not well defined. P is the logarithm of the GDP price deflator. E denotes the logarithm of the nominal exchange rate, SDRs per Japanese Yen. O is the logarithm of the oil price deflated by P. As in the U.S. case, model selection criteria are employed to compare many alternative contemporaneous models, which are used to identify the most appropriate impulse response functions and variance decomposition functions.

6.1 Data and Implementation

The estimation period for Japan is quarterly data from 1983:2 to 2001:2. Data for Y, P, E and oil prices are derived from International Financial Statistics (IFS) of the International Monetary Fund (IMF). Government deficit and debt are obtained from the Bank of Japan. The logarithms of two different monetary aggregates are tried for M: $M1$, and $M2$ (Quasi Money). Money data are also derived from IMF's International Financial Statistics.

The VAR procedure requires the data series of interest to be stationary. The Dickey-Fuller's Z and t test as well as Dickey-Fuller's joint test of unit root are used to examine stationarity of all variables. Table 6-1 presents the results of Augumented Dickey-Fuller's test on the log levels of the variables. The results find that the first differences of *O, f, E, P, Y, M2* and *M2/P* are stationary.

Based on Karras's model, the VAR was estimated in first differences of the log levels of *O, f, P, Y, E and M2,* with the oil price restricted as a random variable. Several alternative specifications for the lag structure and determinants were tested. Based on tests of the lag structure and equation determinants, the VAR model with a constant and four lags was adopted.

After the VAR is estimated and the reduced-form residuals are obtained, estimation of contemporaneous equations as in 4-6 to 4-11 occurs to recover the structural shocks. The same criteria are used as in the U.S. case to select the appropriate model for Japan. The following estimation of the simultaneous equations employs two-stage least squares (2SLS), as employed in the restricted Karras model to recover the six structural shocks, which are used to generate the impulse response and variance decomposition functions.

1. Oil price is restricted as a random variable.

2. Deficit is also restricted as random variable so that $z_t^f = u_t^f$.

3. Use o_t and u_t^f as instrument variables for equation (4-8) to calculate

   $$u_t^s = \hat{z}_t^y - (a_2 o_t + a_3 \hat{z}_t^p).$$

4. Use o_t, u_t^f and u_t^s as instrument variables for equation (4-10) to calculate

   $$u_t^d = z_t^y - \hat{z}_t^y = z_t^y - (a_8 o_t + a_9 \hat{z}_t^f + a_{10} (\hat{z}_t^m - \hat{z}_t^p)).$$

5. Use o_t, u_t^f, u_t^s and u_t^d as instrument variables for equation (4-9) to run regression to calculate $u_t^m = z_t^m - \hat{z}_t^m = z_t^m - (a_4\hat{z}_t^f + a_5\hat{z}_t^p + a_6\hat{z}_t^y + a_7\hat{z}_t^{ex})$.

6. Use o_t, u_t^f, u_t^s, u_t^m and u_t^d as instrument variables for equation (4-11) to calculate $u_t^e = z_t^e - \hat{z}_t^e = z_t^e - (a_{11}o_t + a_{12}\hat{z}_t^f + a_{13}\hat{z}_t^p + a_{14}\hat{z}_t^m + a_{15}\hat{z}_t^y)$.

The estimated parameters show the quantified relationships among the dependent variables in the selected structural equations. Table 6-2 presents the estimated contemporaneous model for the *M2* money aggregate. Some of the estimated coefficients are significant, such as the deficit and exchange rate in the money equation, and deficit in the exchange rate equation, but the others are less significant.

In this restricted model, most signs of the estimated coefficients are consistent with macroeconomic theory, except in the aggregate supply equation. Estimation of aggregate supply shows a positive relationship with respect to international oil price and negative response to price level. The signs of the coefficients on price level do not change regardless of what variables are included to accompany the GDP deflator. In the money equation, the M2 money aggregate is positive with respect to the increase of deficit, output, and exchange rate and is negative in response to the price level, as one might expect. In the aggregate demand equation, aggregate demand decreases in response to the increase of oil price, deficit, and real money supply. In the exchange rate equation, the Japanese Yen depreciates with respect to the increase of fiscal spending, price level and output; nonetheless the Yen appreciates with respect to the increase of oil price, and M2 money. The statistics show that these coefficients are not significant. As mentioned in Chapter 5, the inconsistency in the signs of estimated coefficients may reflect on the real economic situation during the sample period. As one might expect, we find that these signs change over different sample periods.

Once the coefficients of matrix A are estimated, we can identify the structural shocks and their dynamic innovations of the variables of interest through variance decomposition and impulse response functions. As long as the system's covariance matrix is diagonal or all structural equations are identified, the relative efficiency of each alternative will be the same. The identification of contemporaneous equation is used to convert the correlated VAR residuals into structural innovations, which is demonstrated as in equation (4-12)

$$A\Sigma_z A' = \Sigma_u .$$

In detailed expression for the restricted Karras model:

$$\begin{matrix} O & D & P & M & Y & E \end{matrix} \quad \begin{matrix} O & D & P & M & Y & E \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & a_7 \\ a_8 & a_9 & 0 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix} \begin{bmatrix} \sigma_o^2 & \sigma_{od} & \sigma_{op} & \sigma_{om} & \sigma_{oy} & \sigma_{oe} \\ \sigma_{do} & \sigma_d^2 & \sigma_{dp} & \sigma_{dm} & \sigma_{dy} & \sigma_{de} \\ \sigma_{po} & \sigma_{pd} & \sigma_p^2 & \sigma_{pm} & \sigma_{py} & \sigma_{pe} \\ \sigma_{mo} & \sigma_{md} & \sigma_{mp} & \sigma_m^2 & \sigma_{my} & \sigma_{me} \\ \sigma_{yo} & \sigma_{yd} & \sigma_{yp} & \sigma_{ym} & \sigma_y^2 & \sigma_{ye} \\ \sigma_{eo} & \sigma_{ed} & \sigma_{ep} & \sigma_{em} & \sigma_{ey} & \sigma_e^2 \end{bmatrix}$$

$$\begin{matrix} O & D & P & M & Y & E \end{matrix} \quad \begin{matrix} O & D & P & M & Y & E \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & a_7 \\ a_8 & a_9 & 0 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix}' = \begin{bmatrix} u_o^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & u_f^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & u_p^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & u_m^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & u_y^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & u_e^2 \end{bmatrix}.$$

Equation (4-12) can be used to identify structural shocks ($u^o, u^f, u^{ys}, u^m, u^{yd}, u^e$). With all the structural shocks recovered, we can proceed to calculate impulse response functions and variance decomposition functions as shown in Chapter 2. Notice that in the VAR procedure, it is normalized on the price level. Thus, the accumulated IRFs of the price level, M2, RGNP, and exchange rate show their relationship to the price (inflation) shock. The following empirical findings will be based on the restricted Karras model with the *M2* aggregate.

6.2 Empirical Results and Discussion

Significant economic events during the sample period may have a profound impact on the economic variables of interest. It is important to notice what the economy had experienced from 1983 to 2001 for Japan. Among those economic events, two important events during the sample period had impacted the Japanese economy. First, the bubble of the Japanese economy busts since 1992. The price level continues going down, and the economy was stagnant for almost ten years. Second, the financial crisis (capital exodus) in Asian countries since 1998 impacted heavily the Japanese economy. This event not only caused the dramatic depreciation of the Japanese Yen but almost every currency of Asian countries (Thailand, Malaysia, Indonesia, Taiwan and Korea etc.). Also, international capital investment to Mainland China increased since 1998 for its cheaper wage rate and its market opportunity. This substitution effect causes the decrease of investment in Japan, and the rise of the unemployment rate as well. On the other hand, government's ability to control policy variables such as fiscal expense, money supply, and the exchange rate may also impact the estimation of contemporaneous equations. All these impacts will be quantified on average into the following variance decompositions and impulse response functions.

Table 6-3 presents the variance decompositions and mean squared errors for the six variables of interest. The numbers reported indicate the percentage of the forecasted errors in each variable that can be attributed to each of the structural innovations at different horizons. Similar to Karras (1993), the percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead). Also notice that the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks for convenience.

As in Karras's methodology, the oil prices by construction are only affected by their own innovations. They are modeled as a random walk with no feedback from the rest of the variables. Fiscal variation is explained primarily by its own variation. On the price level, as macroeconomic theory postulates, aggregate supply innovations account for about from 85% to 45% variation of inflation over all horizons, while monetary and oil price shocks become more significant in the medium and long run. This finding supports the view that Japan's economy is more sensitive to oil price fluctuations than the U.S. economy, as one might expect. Aggregate demand shocks and monetary shocks dominate all output variation decomposition but are decreasing from 37-16% and 35-19% respectively in all horizons; whereas oil and aggregate supply shocks are getting significant in the medium, and long run on output.

For the exchange rate, in the short run it is explained 65% by its own innovations, decreasing to 32% in the five-year horizon. Aggregate supply shocks account for the exchange rate innovations around 14% during the 5-year time periods. Oil price, deficit and monetary shocks have a trivial effect on the exchange rate in the short-run, but they account for about 17%, 14% and 13% respectively in the medium- and long-run.

Impulse response functions present the responses of variables over time to innovations of each structural disturbance. The accumulated impulse response functions of the output, the price level, and the exchange rate to one standard deviation of the six shocks are shown in Figures 6-1 to 6-3. Figures 6-1 (a) to 6-1 (f) demonstrate accumulated IRFs of output (real GNP) to the six shocks. Figure 6-1 (a) shows that the shocks of oil price increase output by about 0.2 percentage points in the short- and medium- run and the effects drop to -0.8 percentage points in the long run. Figure 6-1 (b) shows that fiscal innovations have negative effects on output over time; the effects decrease output by -0.13 percentage points at first quarter and reach -0.4 percentage points in the long run. Figure 6-1 (c) shows that price (inflation) innovations increase output over time; the effects reach 1 percentage point in the long run. The responses of output to monetary innovations also are positive over time; the responses increase to 0.7 percentage points in the long run (Figure 6-1 (d)). Figure 6-1 (e) shows that aggregate demand shocks have positive effects on output over time, as economic theory postulated; the effects reach 0.3 percentage points in the medium run, but drop to 0.04 percentage points in the long run. Figure 6-1 (f) shows that the exchange rate shocks decrease output over time. In the long run, the effects reach -0.45 percentage points.

Figures 6-2 (a) to 6-2 (f) demonstrate the price level responses with respect to the six shocks. Figure 6-2 (a) shows that the shocks of oil price decrease the price level over time. The effects reach 2 percentage points in the long run. Figure 6-2 (b) shows that fiscal shocks have positive effects on price level only at the first and the second quarters. The effects reach -0.2 percentage points in the long run. Price (inflation) shocks increase the price level over time (Figure 6-2 (c)). The effects increase price level from 0.6 percentage points at the first quarter to 1.6 percentage points in the long run. Figure 6-2 (d) presents that monetary innovations do not increase the price level until the third quarter; however, the price level increases to 0.5 percentage points in the long run. Figure 6-2 (e) shows that aggregate demand shocks decrease the price level over time. The effects reach -0.8 percentage points in the long run. Figure 6-2 (f) shows that the exchange rate shocks have negative effects on the price level over time. The effects reach -0.5 percentage points in the long run.

Figures 6-3 (a) to 6-3 (f) exhibit the accumulative IRFs of the exchange rate to the six shocks. Figure 6-3 (a) shows that the shocks of oil price depreciate the exchange rate over time. The effects reach the peak at -2.4 percentage points at the seventh quarter and decay to -1.5 percentage points in the long run. Figure 6-3 (b) shows that fiscal shocks have negative effects on the exchange rate over time; the effects reach -0.8 percentage points in the long run. Figure 6-3 (c) shows that price (inflation) shocks depreciate the exchange rate by 1 percentage point at the first quarter. The effects reach -1.6 percentage points at the seventh quarter, and decrease to -0.2 percentage points in the long run. Figure 6-3 (d) shows that the responses of the exchange rate to monetary innovations are positive and volatile over time. The effects reach 0.8 percentage points at the first quarter, and increase to 1 percentage point in the medium- and long- run. Figure 6-3 (e) shows that aggregate demand shocks have negative effects on the exchange rate in the short- and medium-run. The effects reach -1 percentage point at the third quarter, and decay in the long run. Figure 6-3 (f) illustrates that exchange rate shocks have positive effects on the exchange rate over time and the effects increase to 3 percentage points in the long run.

In summary, the shocks of oil price decrease output only in the long run, with a mild effect. Surprisingly, fiscal innovations cannot increase output during the time horizons; this could happen if there is a crowding out effect or there is a fiscal budget constraint during the time horizon. The exchange rate shocks decrease output during the time horizons as one might expect. Price (inflation) innovations have mild effects on output in the short run, but surprisingly output increases in the long run. Aggregate demand shocks have only short-term effects on output as macroeconomic theory postulates; but the responses of output to monetary innovations are positive and increasing over time.

For the accumulated IRFs of the price level to the six shocks, oil and fiscal shocks increase price level only in the short run. Price (inflation) shocks have more significant effect on the price level, especially in the long run while aggregate demand has a mild and positive effect on output only in the short run. As expected, money shocks are important in causing inflation in the long run. The price level has little response to the exchange rate shocks over all time horizons.

For the accumulated IRFs of the exchange rate to the six shocks, same as the U.S. result, the impact of fiscal innovations on the exchange rate appears to depreciate the Japaness currency over time. Price (inflation) shocks tend to depreciate the Japanese currency in the time horizons as one might expect. Aggregate demand appreciates the Yen only in the long run. Surprising, monetary shocks do not depreciate Japan's currency. Macroeconomic theory postulates that excess in money supply would cause inflation, and decrease the real interest rate, thus depreciating the exchange rate. However, if the money shocks have a money illusion effect and the additional money is used to finance domestic investment for continued economic expansion, the exchange rate might not depreciate due to money shocks.

It is also interesting to notice that international oil price shocks seem to have little impact on the price level and output but have larger impact on the exchange rate in the short run, as shown in the case of Taiwan. Fiscal shocks have significantly greater impact on the exchange rate than output over time. Price (negative supply) shocks have increasing impact on output in the long run; the exchange rate is more sensitive to the supply shocks; and surprisingly output is not decreased by the supply shocks as one might expect; this phenomena might be due to the oversea investment which decreased manufacturing costs during 1980s and 1990s.

Monetary shocks have a mild effect on the price level, output, and the exchange rate. Demand shocks have hump-shape effects on output as one might expect, and the exchange rate is sensitive to the shocks especially in the short run. Exchange shocks have only mild effects on output and price level, but have a dominant effect on itself over time.

CHAPTER 7

THE CASE OF KOREA

The case of Korea follows Karras's methodology with the six variables. In this model, *Y* is the logarithm of real GNI and *f* is the ratio of the logarithm of the real government deficit to government debt subtracted from one. We use this manipulation because some of the seasonally adjusted budget deficits are still positive; in this case the log level of the fiscal variable is not well defined. *P* is the logarithm of the GDP price deflator. *E* denotes the logarithm of the nominal exchange rate – SDRs per South Korea's Won. *O* is the logarithm of the oil price deflated by *P*. As in the U.S. case, the model selection criteria are employed to compare many alternative contemporaneous models. Then, the selected model is used to identify the most appropriate impulse response functions and variance decomposition functions.

7.1 Data and Implementation

The estimation period for Korea is quarterly data from 1980:1 to 2000:2. Data for *Y, P, E* and Oil price data are obtained from the International Monetary Fund. These data are derived from IMF's International Financial Statistics. The logarithms of two different monetary aggregates are tried for *M: M1,* and *M2* (Quasi Money). Money data are also derived from IMF's International Financial Statistics.

The VAR procedure requires the data series of interest to be stationary. The Dickey-Fuller's Z and t test as well as Dickey-Fuller's joint test of unit root are used to examine the stationarity of all the variables. Table 7-1 presents the results of

Augumented Dickey-Fuller's test on the log levels of the variables. The results find that the first difference of *O, f, E, P, Y, M2,* and *M2/P* are stationary.

Based on Karras's results, a VAR was estimated in first differences of the log levels of *O, f, P, Y, E,* and *M2,* with the oil price restricted as a random variable. Several alternative specifications for the lag structure and determinants were tested. Based on tests of lag structure and equation determinants, the VAR model with a constant and four lags is adopted.

After the VAR is estimated and the reduced-form residuals are obtained, estimation of contemporaneous equations as in 4-6 to 4-11 occurs to recover the structural shocks. The same criteria are used as in the U.S. case to select the appropriate model for Korea. The following estimation of the simultaneous equations employs two-stage least squares (2SLS), as employed in the restricted Karras model to recover the six structural shocks, which are used to generate the impulse response and variance decomposition functions.

1. Oil price is restricted as a random variable.
2. Deficit is also restricted as random variable so that $z_t^f = u_t^f$.
3. Use o_t and u_t^f as instrument variables for equation (4-8) to calculate

   $u_t^s = \hat{z}_t^y - (a_2 o_t + a_3 \hat{z}_t^p)$.

4. Use o_t, u_t^f and u_t^s as instrument variables for equation (4-10) to calculate

   $u_t^d = z_t^y - \hat{z}_t^y = z_t^y - (a_8 o_t + a_9 \hat{z}_t^f + a_{10}(\hat{z}_t^m - \hat{z}_t^p))$.

5. Use o_t, u_t^f, u_t^s and u_t^d as instrument variables for equation (4-9) to run regression to calculate $u_t^m = z_t^m - \hat{z}_t^m = z_t^m - (a_4 \hat{z}_t^f + a_5 \hat{z}_t^p + a_6 \hat{z}_t^y + a_7 \hat{z}_t^{ex})$.

6. Use o_t, u_t^f, u_t^s, u_t^m and u_t^d as instrument variables for equation (4-11) to calculate

$$u_t^e = z_t^e - \hat{z}_t^e = z_t^e - (a_{11}o_t + a_{12}\hat{z}_t^f + a_{13}\hat{z}_t^p + a_{14}\hat{z}_t^m + a_{15}\hat{z}_t^y).$$

The estimated parameters show the quantified relationships among the dependent variables in the selected structural equations. Table 7-2 presents the estimated coefficients from the restricted Karras model for the M2 money aggregate. Some of the estimated coefficients are significant such as real GNI and the GDP deflator in the monetary equation; and oil price, GDP deflator, and money variables in the exchange rate equation.

In the restricted model, most signs of the estimated coefficients are consistent with macroeconomic theory. The aggregate supply has a positive relationship with respect to price level but its response to oil price is also positive. In the money equation, money supply has an inverse relation to the increase of real GNI, GDP deflator and deficit and is increased in response to exchange rate appreciation. In the aggregate demand equation, aggregate demand decreases when the price level and international oil prices increase. Aggregate demand also increases in response to the real money supply, but the coefficient appears to be rather large. In the exchange rate equation, the Korean Won has a negative relation to the oil price, GDP deflator, money supply and real GNI. Only when fiscal expense increases, the Korean Won tends to appreciate. As mentioned in Chapter 5, the inconsistency in the signs of estimated coefficients may reflect on the real economic situation during the sample period. As one might expect, we find that these signs change over different sample periods.

Once the coefficients of matrix A are estimated, we can identify the structural shocks and the dynamic innovations of these variables of interest through variance decomposition and impulse response functions. As long as the system's covariance matrix is diagonal or all structural equations are identified, the relative efficiency of each alternative will be the same. The identification of the contemporaneous equation is used to convert the correlated VAR residuals into structural innovations which is demonstrated in equation (4-12)

$$A\Sigma_z A' = \Sigma_u .$$

In detailed expression for the restricted Karras model:

$$\begin{matrix} O & D & P & M & Y & E \end{matrix} \quad \begin{matrix} O & D & P & M & Y & E \end{matrix}$$
$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & a_7 \\ a_8 & a_9 & 0 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix} \begin{bmatrix} \sigma_o^2 & \sigma_{od} & \sigma_{op} & \sigma_{om} & \sigma_{oy} & \sigma_{oe} \\ \sigma_{do} & \sigma_d^2 & \sigma_{dp} & \sigma_{dm} & \sigma_{dy} & \sigma_{de} \\ \sigma_{po} & \sigma_{pd} & \sigma_p^2 & \sigma_{pm} & \sigma_{py} & \sigma_{pe} \\ \sigma_{mo} & \sigma_{md} & \sigma_{mp} & \sigma_m^2 & \sigma_{my} & \sigma_{me} \\ \sigma_{yo} & \sigma_{yd} & \sigma_{yp} & \sigma_{ym} & \sigma_y^2 & \sigma_{ye} \\ \sigma_{eo} & \sigma_{ed} & \sigma_{ep} & \sigma_{em} & \sigma_{ey} & \sigma_e^2 \end{bmatrix}$$

$$\begin{matrix} O & D & P & M & Y & E \end{matrix} \quad \begin{matrix} O & D & P & M & Y & E \end{matrix}$$
$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_2 & 0 & a_3 & 0 & 1 & 0 \\ 0 & a_4 & a_5 & 1 & a_6 & a_7 \\ a_8 & a_9 & 0 & a_{10} & 1 & 0 \\ a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 \end{bmatrix}' = \begin{bmatrix} u_o^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & u_f^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & u_p^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & u_m^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & u_y^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & u_e^2 \end{bmatrix}.$$

Equation (4-12) can be used to identify structural shocks ($u^o, u^f, u^{ys}, u^m, u^{yd}, u^e$). With all the structural shocks recovered, we can proceed to calculate impulse response functions and variance decomposition functions as shown in Chapter 2. Notice that the VAR procedure is normalized on the price level. Thus, the accumulated IRFs of the price level, M2, RGNP, and the exchange rate show their relationship to the price (inflation) shock. The following empirical findings will be based on the restricted Karras model with the *M2* aggregate.

7.2 Empirical Results and Discussion

Since significant economic events during the sample period may have profound impacts on the economic variables of interest for the Korean economy, it is important to note what the economy had experienced from 1980 to 2000. Two important events during the sample period had severe impacts on Korea's economy. First, the second world oil crisis of 1979 severely impacted Korea's economy. The crisis may cause a higher price level and decrease real GNI during the following two years in Korea. Second, the financial crisis (capital exodus) in Asian countries since 1998 impacted the Korean economy severely. The Korean currency deeply depreciated due to the tremendous foreign debt. This event not only caused the dramatic depreciation of the Korean Won but almost every currency of Asian countries (Thailand, Malaysia, Indonesia, Taiwan and Japan etc.). In addition, since 1998 international investment capital moved to Mainland China for the cheaper labor rate and domestic market opportunity; this substitution effect might cause the decrease of investment in Korea, and the rise of unemployment rate as well. On the other hand, government ability to control the policy variables such as fiscal expenses, money supply, and exchange rate may impact the estimates of the contemporaneous equations. All these impacts will be quantified on average into the variance decompositions and impulse response functions.

Table 7-3 presents the variance decompositions and mean squared errors for the six variables of interest. The numbers reported indicate the percentage of the forecasted errors in each variable that can be attributed to each of the structural innovations at different horizons. Similar to Karras's article (1993), the percentages are reported for only four horizons, which will be interpreted as the short run (one quarter ahead), the medium run (4 or 8 quarters ahead), and the long run (20 quarters ahead). Also notice that the AS and AD shocks that follow represent non-oil aggregate supply and non-fiscal, non-monetary aggregate demand shocks for convenience.

Oil price by construction is only affected by its own innovations. It is modeled as a random walk with no feedback from the rest of the variables. Fiscal variation is explained by its own variation, 90-75%. On the price level, as macroeconomic theory postulates, aggregate supply innovations account for about 60% to 42% variation for all horizons; while the exchange rate and oil price shocks are also significant over the time horizons. This finding also indicates that the Korean economy is sensitive to oil price fluctuations. Monetary variation is explained by its own shocks. Monetary shocks also dominate the output variance decomposition in all horizons.

For the exchange rate, in the short run it is explained 70% by its own innovations, decreasing to 54% in the five-year horizon. Aggregate demand and oil price shocks account for the exchange rate innovations around 13% and 17% in the medium and long run.

Impulse response functions present the responses of variables over time to innovations of the structural disturbances. The accumulated impulse response functions of output, the price level, and the exchange rate to one standard deviation of the six shocks are shown in Figures 7-1 to 7-3. Figures 7-1 (a) to 7-1 (f) demonstrate accumulated IRFs of output (real GNP) to the six shocks. Figure 7-1 (a) shows that the shocks of oil price have a mixture of positive and negative effects on output in the short run, and the effects have -3 percentage points in the long run. Figure 7-1 (b) shows that fiscal innovations have negative effects on output over time except at the second quarter. The effects decrease the output at -1 percentage point in the long run. Figure 7-1 (c) shows that price (inflation) innovations decrease output in the short and medium run; the effects reach 1.5 percentage points in the long run. The responses of output to monetary innovations are positive over time; the responses reach 25 percentage points at the first quarter and drop to 5 percentage points in the long run (Figure 7-1 (d)). Figure 7-1 (e) shows that aggregate demand shocks have positive effects on output over time, as economic theory postulates; the effects reach 10 percentage points in the long run. Figure 7-1 (f) illustrates that the exchange rate shocks increase output over time. In the long run, the effects reach 7 percentage points.

Figures 7-2 (a) to 7-2 (f) demonstrate the price level responses with respect to the six shocks. Figure 7-2 (a) shows that the shocks of oil price decrease the price level over time. The effects reach 2.5 percentage points in the long run. Figure 7-2 (b) shows that fiscal shocks have positive effects on price level over time. The effects reach 1.2 percentage points in the long run. Price (inflation) shocks increase the price level over time (Figure 7-2 (c)). The effects increase the price level from 1.3 percentage points at the first quarter to 1.1 percentage points in the long run. Figure 7-2 (d) shows that monetary innovations decrease the price level over time; the price level decreases to -0.5 percentage points in the long run. Figure 7-2 (e) shows that aggregate demand shocks decrease the price level over time except in the short run. The effects reach -1 percentage point in the long run. Figure 7-2 (f) shows that the exchange rate shocks have positive effects on the price level over time. The effects reach 1 percentage point in the long run.

Figures 7-3 (a) to 7-3 (f) exhibit the accumulative IRFs of the exchange rate to the six shocks. Figure 7-3 (a) shows that the shocks of oil price depreciate the exchange rate over time. The effects reach the peak at -5.5 percentage points at the seventh quarter and decay to -5 percentage points in the long run. Figure 7-3 (b) shows that fiscal shocks have positive effects on the exchange rate over time; the effects reach 3 percentage points in the long run. Figure 7-3 (c) illustrates that price (inflation) shocks depreciate the exchange rate over time. The effects reach -1.8 percentage points in the long run. Figure 7-3 (d) shows that the responses of the exchange rate to monetary innovations are negative over time. The effects are from -1.5 to -2 percentage points over the time horizon. Figure 7-3 (e) shows that aggregate demand shocks have positive effects on the exchange rate only in the short run; the shocks have negative effects in the medium and long run. The effects reach 2.2 percentage points at the first quarter, then reach -0.5 percentage points in the long run. Figure 7-3 (f) shows that exchange rate shocks have positive effects on the exchange rate over time and the effects have 5.5 percentage points in the medium and long run.

In summary, for the accumulated impulse response functions of output (real GNI) to the six shocks, the shocks of oil price mildly decrease output only in the long run. Fiscal innovations increase output only in the short run. In the long run, the effects become negative; this could happen if there is a crowding out effect or if there is a fiscal budget constraint during the time horizon. The exchange rate shocks decrease output during the time horizons as one might expect. Price (inflation) innovations decrease output in the short run, but surprisingly the output increases in the long run. Aggregate demand shocks not only have short-term but also long-run effects on output. The responses of output to monetary innovations are increased significantly in the first quarter but decreased after the second quarter.

For the accumulated IRFs of the price level to the six shocks, surprisingly, oil shocks do not inflate the price level during the time period, while fiscal shocks increase the price level over the periods. Price (inflation) shocks have positive effects on the price level, especially in the short run, while money shocks do not inflate the price level during the sampling period. Aggregate demand has mild and positive effects on the price level only in the short run. The price level responds highly to the exchange rate shocks over all time horizons.

For the accumulative IRFs of the exchange rate to the six shocks, oil shocks tend to depreciate the Korean Won. As in the U.S. result, the impact of fiscal innovations on the exchange rate appears to depreciate the Korean currency over time. Price (inflation) shocks tend to depreciate the Korean currency over the time horizons. Monetary shocks depreciate the Korean currency during the time horizons. Aggregate demand appreciates the Won only in the short run. Exchange rate shocks have positive effects on Korea's currency.

CHAPTER 8

SUMMARY, CONCLUSION AND RECOMMENDATIONS

8.1 Summary

Structural VARs are different from traditional VARs in that the former employs macroeconomic theories as restrictions to derive the impulse response and variance decomposition functions. The structural VAR method estimates parameters by imposing contemporaneous and/or long run structural restrictions. The estimation of these contemporaneous equations and/or long run structural restrictions is consistent with macroeconomic theories and is used to transform reduced-form residuals into structural innovation. This paper employs the restricted version of Karras (1993) model and uses generally accepted macroeconomic theories to investigate the importance of six different kinds of structural shocks for the macroeconomic fluctuations for the U.S. from 1973 to 2001, Taiwan from 1981 to 2000, Japan from 1983 to 2001 as well as Korea from1980 to 2000. The six structural innovations postulated were: oil, fiscal, price, (non-oil) aggregate supply, monetary, (non-fiscal, non-monetary) aggregate demand, and exchange rate disturbances. Many alternative contemporaneous restrictions have been tried to identify the more appropriate result.

It is interesting to find that the estimated coefficients of price and money variables in the exchange rate contemporaneous equation are rather large for the case of Taiwan; and this is also shown in the coefficient of the real money variable in the aggregate demand equation in the case of Korea. But the problems are not shown in the cases of the

United States and Japan. One possible reason for this finding is that the size of economy for Taiwan and Korea are rather small compared to the U.S. The residuals from VARs might become more volatile when a small economy experiences such significant shocks as those to the international oil price, the exchange rate and the Asian Financial Crisis. That is, if some of the VAR residuals are found unusual or highly volatile (these observations are outliers from a statistical point of view), the estimation of contemporaneous equations would reflect and convert these effects into the IRFs and FEVDs. Thus, even though the same restricted Karras model are used to derive the IRFs and FEVDs for the four countries, some of the IRFs and FEVDs for these countries might be inconsistent each other. These inconsistencies might be the case because each country has its own economic experience, characteristics and ingredients. Despite these drawbacks, however, most of the results do have consistencies and comply with most accepted macroeconomic theories. Based on the restricted Karras model, the comparisons for the quantified accumulated IRFs and FEVDs for these countries are discussed as follows:

1. Forecasted error variance decomposition

    (1) Fiscal variation is dominated by its own shocks for the U.S., Taiwan, Japan, and Korea.

    (2) On the variation of the price level, the U.S. economy shows that aggregate supply and M2 money shocks are more significant. For Japan, aggregate supply and oil price shocks are more important. For Korea, aggregate supply, exchange rate and oil price shocks are significant; and for Taiwan, the variation is explained mainly by aggregate supply, followed by oil price variables.

(3) Aggregate demand explains about 87-68% for the variation of M2 money in all horizons for the U.S.; for Japan, monetary, oil price and aggregate demand shocks are more important for the variation. In Korea, monetary shocks are the primary factor; and for Taiwan, monetary variation is explained by its own, followed by exchange rate, oil price and fiscal shocks.

(4) For output, the results show that monetary and aggregate supply shocks dominate the variation during the horizons in the U.S. economy. But in Japan, monetary policy is the main source for output variation, followed by aggregate demand and oil price shocks. In Korea, monetary policy is found to be the primary source of output variation. Whereas in Taiwan, output variation is shared by aggregate demand and the exchange rate, followed by aggregate supply shocks.

(5) The exchange rate is primarily explained by its own innovations in the U.S., over 80% in all horizons. In Japan, the variation is explained by its own for 65-32%, followed by monetary, oil price and aggregate supply shocks, which are equally important. In Korea, the exchange rate accounts for 70-54% of its variation. Oil price and aggregate demand shocks are also important after midterm. In Taiwan, the exchange rate is found to be less important to its own variation. Instead, monetary shocks are the most important source for the variation, followed by deficit shocks.

2. Accumulated impulse response functions:

(1) In response to the oil shocks, macroeconomic theory postulate that this effect, if longer than one might expect, would increase price level and decrease output . For the U.S., the price level goes up and real GNP decreases as one expect. For

Japan, international oil price shocks do not increase the price level except at the first quarter; the shocks decrease output only in the long run. For Taiwan, the oil shocks decrease output in the medium and long run and mildly decrease the price level over time. For Korea, the oil shocks decrease output in the long run and decrease the price level over time.

(2) Keynesian theory postulates that fiscal innovations shift the aggregate demand curve to the right, and this might have positive effects on output and price level. This is shown in the United States. For Taiwan, the shocks have a mixture of positive and negative effects on the output in the short run and positive effects on the price level over time. For Japan, the price level positively responds to the fiscal shocks only for the very short run, but the output are negative over time. In Korea, fiscal shocks increase the price level; the effects increase output only at the second quarter. Notice that if there is a crowding out effect or if there is a fiscal budget constraint during the time horizon, output might become negative to the fiscal shocks.

(3) The Mundell-Flemming model proposes that increases in budget deficit tend to appreciate the exchange rate. We find fiscal innovation appears to appreciate the exchange rate for Taiwan and Korea, but not the U.S. and Japan. However, as Karras (1993) indicated, if the budget deficits are monetized or if budget deficits have no effect on the interest rate (Ricardian Equivalence holds), the exchange rate will not be appreciated by the fiscal shocks.

(4) Keynesian theory proposed that price (inflation) shocks would increase the expected inflation. This would decrease output (recessionary gap) and increase

the price level; and with the higher price level and lower output, the exchange rate tends to depreciate. For the U.S. and Taiwan, price (inflation) shocks increase the price level and decrease output. Whereas, Japan and Korea show the same effect on the price level, but their output decreases only in the short run. Japan's output is decreased by the price shocks only at the first quarter.

(5) According to theory, money shocks would decrease the interest rate; with money illusion, output and price level would go up. The responses of output and the price level to monetary innovations are all found positive for the U.S., Taiwan and Japan. For Korea, money shocks increase output but have negative effects on the price level.

(6) Economic theory postulates that aggregate demand shocks would increase output and the price level only in the short run. This is shown in the case of the U.S. In the cases of Taiwan, Korea and Japan, aggregate demand shocks increase output over time. In Korea, aggregate demand shocks have temporary effects on the price level; but for the cases of Japan and Taiwan, the price level is not increased.

(7) With a flat price level, positive nominal exchange rate shocks would increase real exchange rate, then decrease output and price level due to the decline in net exports; For the U.S. results, price level decreases in response to exchange rate shocks while output increased. For Japan, the price level and output are decreased in response to the exchange rate shocks. While in Korea, price level and output are found positive. In the case of Taiwan, the price level has mixed effects in the short run, while output decreases only in the short run.

8.2 Conclusion

In comparing the results for the four countries, this paper finds that the estimated parameters of the contemporaneous equations might be inconsistent with each other. From an economic point of view, this inconsistency might result from the size of the economy, economic events experienced, as well as dramatic changes in policy variables, such as money supply and the exchange rate. The coefficient estimates from the different countries might not be consistent and might result in different structural shocks for variance decompositions and impulse responses. The reason for the difference is that information asymmetry and market inefficiency as well as the change of government policies might impact the estimates of the contemporaneous parameters, which in turn influence the fluctuation of economic variables and their IRFs and FEVDs as well. In addition, economic authorities might change these economic policy variables by different rules (e.g., past information or rational expectation) in order to reach different economic goals in the short-run; moreover, some policy variables may be out of the control of policy makers during severe economic shocks, just like the case of Korea during the Financial Crisis in Asia.

In this paper, the restricted Karras model is used for identifying impulse response functions and variance decomposition functions for the four countries. Based on the setting of the six shocks, the results of these sampled countries support the following propositions to some extent:

(1) Monetary innovation increases output and price level.

(2) Aggregate demand disturbances increase the output for the four countries. The shocks increase the price level in the short run in the U.S. and Korea. In Taiwan and Japan, aggregate demand shocks have mildly negative effects on the price level.

(3) In the cases of the U.S. and Japan, increases in the budget deficit tend to depreciate the exchange rate; the effect is even more obvious in the long term. In the cases of Taiwan and Korea, the exchange rate appreciates in response to the fiscal shocks. As Karras (1993) indicated, if the budget deficits are monetized or if budget deficits have no effect on the interest rate (Ricardian Equivalence holds), the exchange rate will not appreciate.

(4) Price (inflation) shocks have permanent effects on output for the U.S. and Taiwan. But the results for the cases of Japan and Korea are controversial in that their outputs are not decreased by the inflation shocks in the medium- and long- run.

(5) Price (inflation) shocks have long run effects on the price level. With rational expectations, people might expect higher inflation with the price shock. In the U.S., price (inflation) shocks have a long-run effect on the price level. This finding is also shown in Japan, Taiwan and Korea.

(6) Fiscal policy, monetary policy, AS, and AD are important for the business variation for the four countries, though the order of significance for the four variables might vary.

(7) Inflation is the mixed effect of many individual shocks—On the variation of price level, the U.S. economy shows that aggregate supply and M2 money are

more significant. For Japan, aggregate supply and oil price shocks play a more important role. For Korea, aggregate supply, exchange rate and oil price shocks are significant; and for Taiwan, the variation is explained predominantly by aggregate supply, followed by oil price shocks.

(8) This research also, to some extent, supports Blanchard and Watson's view that monetary, fiscal, AS and AD are important sources of the variation of the business cycles.

8.3 Recommendations

The Structural VAR model has its own drawback; Keating (1992) found significant discrepancy existing between long-run restrictions and contemporaneous restrictions models. He found that the structural parameters in the long-run restrictions model are more precisely estimated than parameters in the contemporaneous model. The model with long-run restrictions yields sensible results, while the results from the contemporaneous model are somehow inconsistent with standard economic theories. He concluded that long-run structural VARs might yield theoretically predicted results more frequently than VARs identified with short-run restrictions. One reason for this, he mentioned, is that economic theories may often have similar long-run properties but different short-run features. Keating (1990) also indicated that contemporaneous zero restrictions may be inappropriate in an environment with forward-looking agents who have rational expectations. He contended that any observable contemporaneous variable might provide information about future events. The implication from Keating's papers is that different short-run restrictions can be obtained from alternative assumptions about available information. For example, Stock and Watson (2001) use the "Taylor rule" in which the Federal Reserve is modeled as setting the interest rate based on past rates of inflation and unemployment to compare the forward-looking behavior, which is modeled as the Fed reacts to the forecast of inflation and unemployment four quarters into the future.

As Lucas (1977) indicated, the change of macroeconomic policy variables is a rule for systematically changing that variable in response to market conditions, therefore the institution of a nontrivial policy would end the exogeneity and change the expectation formation rule and the normalized reduced form. Moreover, as indicated by Blanchard and Watson (1986), the accumulation of small, unimportant shocks can lead to economic fluctuations similar to the fluctuations caused by infrequent large shocks. If there are many small shocks not included in this model or if these small shocks are quantified into the six primary shocks used for Karras's structural VAR model, then the impulse response and variance decomposition functions in our research might be smeared so as to reach a misleading results. Further investigation on other countries not only using contemporaneous restrictions but also using long-run restriction, or a mixed model may be helpful in finding the better result. On the other hand, it also would be interesting to know how business cycles responds to those shocks that are interested during recession and expansion periods, for different stages of economies, and for different sizes of economies.

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APPENDIXES

APPENDIX A

TABLE 3-1

CHANGE OF ECONOMIC GROWTH RATE AND INFLATION
(Annual Rate %)

Year	Real GNP Growth Rate	Inflation Rate: Change of Weighed Producer Price Index	Inflation Rate: Change of CPI	Inflation Rate: Change of GNP Deflator
1961-71 Annual Average	10.2	1.6	2.9	3.6
1971	12.9	0.02	2.8	3.1
1972	13.3	4.5	3	5.8
1973	12.8	22.9	8.2	14.9
1974	1.1	40.6	47.5	32.3
1975	4.2	-5.1	5.2	2.3
1976	13.5	2.8	2.5	5.6
1977	9.9	2.8	7	6.2
1978	13.9	3.5	5.8	4.7
1979	8.1	13.8	9.8	11.3
1980	6.6	21.5	19	16.1
1981	5.5	7.6	16.3	12.1

Source: Statistics Department, Ministry of Finance.

TABLE 3-2

VARIATION OF INFLATION RATE, IMPORT PRICE, AND MONEY SUPPLY (Annual Rate %)

Year	Change of Gross Price Index*	Change of Import Price*	Growth Rate of Money Supply (M1)**
1961-71 Annual Average	1.6	1.7	17.9
1970	2.7	3.6	11.3
1971	0.02	5.1	24.8
1972	4.5	8	37.9
1973	22.9	22.1	49.3
1974	40.6	47	7
1975	-5.1	-5	26.9
1976	2.8	2.1	23.1
1977	2.8	7.7	29.1
1978	3.5	9.2	34.1
1979	13.8	16.6	7
1980	21.5	20.2	19.9
1981	7.6	8.6	11.1

Source: Directorate General of Budgets, Account & Statistics, Executive Yuan.

Source: International Monetary Fund, International Financial Statistics, 1981.

Source: Statistics Department, Ministry of Finance.

* Change of gross price index and import price are compared with the annual average of the last year.

** Money supply growth rate is calculated with the M1 by the end of each year.

TABLE 3-3

FACTORS OF THE CHANGE OF MONEY SUPPLY DECOMPOSITION (UNIT: MILLION)

End of Year	Change of Money Supply (M1)*	Net Change of Foreign Assets	Net Change of Government Fiscal Balance	Change of Excess Money Supply of Banks**	Change of The Other Factors
1971	7945	10067	-648	93	-1567
1972	15146	24227	-5885	-2461	-735
1973	27184	20619	-18110	25762	-1087
1974	5769	-24444	1292	41977	-13056
1975	23701	-7910	-8603	32839	7375
1976	25780	37201	-2706	-7940	-775
1977	40015	40414	14	-601	188
1978	60504	61823	-24543	17591	5633
1979	16624	-6353	-30196	68703	-15530
1980	50741	-13046	6191	71397	-13801
1981	34020	32754	31900	5945	-36579

Sources: Economic Research Center of Central Bank

* Change of Money Supply (M1) = net change of foreign assets + net change of government fiscal balance + change of excess money supply of banks + change of the other factors

** Change of Excess Money Supply of Banks = change of banks' loan and investment - (change of bank's (saving + transferable CD + banks' net value))

TABLE 3-4

INTERNATIONAL MAJOR ACCOUNTS OF BALANCE OF PAYMENTS (UNIT: MILLION US$)

Year	Current Account	Direct Net Investment	Long-Term Net Capital	Basic Balance of Payments*	Syndicate International Balance of Payments**
1970	1	61	62	124	135
1971	173	52	37	262	254
1972	513	24	45	582	607
1973	566	61	137	764	610
1974	-1113	83	304	-726	-597
1975	-589	34	497	-58	-149
1976	292	68	531	891	981
1977	920	44	305	1269	1132
1978	1669	110	243	2022	1951
1979	241	122	361	724	96
1980	-965	119	1087	241	-127
1981	497	101	738	1336	1299

Source: Economic Research Center of Central Bank

* Basic balance of payments = current account + direct net investment + long-term net capital

** Syndicate international balance of payment = net change of foreign - country assets of domestic banks

TABLE 3-5

PURCHASING POWER PARITY (PPP), EFFECTIVE EXCHANGE RATE INDEX (EER), AND REAL EXCHANGE RATE INDEX (REER = EER/PPP)

Year	PPP		EER		EER/PPP	
	Export Only*	Total Trade Value*	Export Only	Total Trade Value	Export Only	Total Trade Value
1970	114	116.1	109.2	117	95.8	100.8
1971	116.1	118.1	103.9	113.2	89.5	95.9
1972	115.9	116.9	100	104.8	86.3	89.6
1973	107.3	108.1	101	103.1	94.1	95.4
1974	90.2	93.4	101.7	106.3	112.7	113.8
1975	103.3	105.1	102.9	106.5	99.6	101.3
1976	106.2	107.8	103.9	107.5	97.8	99.7
1977	108.5	109.6	101.3	103.2	93.4	94.2
1978	110.2	110.1	97.3	96.1	88.3	87.3
1979	106.8	106.2	99.6	99.1	93.3	93.3
1980	100	100	100	100	100	100
1981	100.4	99.4	100.1	99.3	99.7	99.9

Source: Directorate General of Budgets, Account & Statistics, Executive Yuan.

Source: International Monetary Fund, International Financial Statistics, 1981.

Source: Statistics Department, Ministry of Finance.

* Export value and total trade value are derived from the major trade counterparts.

TABLE 3-6

INTEREST RATE ADJUSTMENT ON JANUARY 27, 1974
(UNIT: ANNUAL RATE %)

	Adjustment Date		
	24-Oct-73	**27-Jan-74**	**Net Change**
Saving Interest Rate			
One-Month CD	7	10	3
Three-Month CD	8	11.5	3.5
Six-Month CD	9	12.5	3.5
Nine-Month CD	9.5	13	3.5
One-Year CD	11	15	4
Two-Year CD	11.5	15	3.5
Three-Year CD	12	15	3
Weighted Average Change Rate			3.43
Loan Interest Rate			
Non-Mortgage Rate	13.75	17.5	3.75
Mortgage Rate	13.25	16.5	3.25
Weighted Average Change Rate			3.5

Sources: Economic Research Center of Central Bank

TABLE 3-7

AMOUNT OF CERTIFICATE DEPOSITS AND CHANGE OF GROSS PRICE INDEX (UNIT: MONTH RATE)

Month	Year	Total Sum of CD and Saving Account Deposit (Million NT$)	Change of CD and Saving Account Deposit (Million NT$)	Growth Rate of Total Sum of CD and Saving Account Deposit (%)	Growth Rate of Gross Price Index (%)
	May-73	105776	3238	3.2	0.9
Jun		108217	2441	2.3	2
Jul		110501	2284	2.1	3.1
Aug		113790	3289	3	4.5
Sep		114744	954	0.8	4.6
Oct		114322	-422	-0.4	4.3
Nov		114114	-208	-0.2	2.8
Dec		114543	429	0.4	4.6
	Jan-74	112706	-1837	-1.6	12.9
Feb		114524	1818	1.6	12.9
Mar		118140	3616	3.2	-1.8
Apr		121958	3818	3.2	-3
May		125849	3891	3.2	-1.8
Jun		130775	4926	3.9	-1.1
Jul		135543	4768	3.6	-0.9
Aug		140933	5390	4	-0.1
Sep		145430	4497	3.2	-0.9
Oct		149728	4298	3	-1.4
Nov		152375	2647	1.8	-1.5
Dec		157638	5263	3.5	-0.1

Sources: Economic Research Center of Central Bank

TABLE 3-8

ESTIMATED DECREASE OF TAX REVENUE IN 1974

Taxes	Tax Revenue (Billion NT$)	Estimated Tax Deduction (Billion NT$)	Tax Decrease (%)
Income Tax	15.77	0.36	2.3
Tariff	26.66	6.74	25.3
Sales Tax	13.9	3.94	28.3
Harbor Tax	5.88	0.07	1.2
Total Sum	86.45	11.11	12.9

Sources: Council of The Economic Development & Planning, Executive Yuan.

TABLE 3-9

THE INVESTMENT OF BIG-TEN INFRASTRUCTURES AND REAL GNP GROWTH RATE

Year	Big-Ten Infrastructures Divided By Total National Investment (%)	Real GNP Growth Rate (%)
1973	4.5	12.8
1974	4.5	1.1
1975	19.3	4.2
1976	19.6	13.5
1977	13.1	9.9
1978	8.1	13.9

Sources: Council of the Economic Development & Planning, Executive Yuan.

Sources: Directorate-General of Budgets, Account & Statistics, Executive Yuan.

Table 4-1

Variance Decompositions for The U.S.

Percentage of OIL Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of Deficit Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
4	10.9%	66.9%	5.2%	9.4%	0.8%	6.8%
8	12.9%	63.2%	5.3%	9.1%	1.8%	7.8%
20	13.1%	62.6%	5.3%	9.5%	1.8%	7.7%

Percentage of Price Level Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	0.1%	16.8%	24.5%	28.5%	24.2%	5.8%
4	10.8%	12.2%	16.8%	40.6%	14.1%	5.5%
8	13.5%	7.9%	10.1%	54.6%	9.3%	4.5%
20	9.3%	5.5%	6.8%	66.1%	8.6%	3.7%

Percentage of Monetary (M2) Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	0.7%	0.2%	4.6%	20.9%	69.5%	4.2%
4	18.5%	2.6%	4.1%	15.1%	55.8%	3.9%
8	18.5%	2.8%	5.9%	16.5%	50.9%	5.4%
20	17.8%	2.5%	4.9%	27.4%	42.6%	4.8%

Percentage of Real GNP Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	0.7%	5.1%	76.6%	8.6%	7.3%	1.7%
4	4.7%	5.7%	62.3%	15.9%	9.3%	2.1%
8	17.7%	8.1%	49.0%	14.1%	8.9%	2.2%
20	17.7%	8.3%	48.4%	14.3%	9.1%	2.2%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	0.6%	8.8%	0.9%	29.2%	2.0%	58.4%
4	8.8%	9.7%	1.8%	24.4%	1.9%	53.3%
8	8.9%	10.1%	2.3%	26.1%	3.3%	49.5%
20	9.4%	10.3%	2.3%	26.2%	3.4%	48.4%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	13.5%	0.7%	0.2%	0.7%	0.6%	2.3%
4	13.5%	1.0%	0.3%	0.8%	0.7%	2.4%
8	13.5%	1.2%	0.3%	0.8%	0.7%	2.4%
20	13.5%	1.5%	0.4%	0.8%	0.7%	2.5%

Table 4-2

Stationarity Test for U.S.

Using Logarithm Data from 74:01 to 101:02 with First Difference Testing the Null Hypothesis of a Unit Root in				
Variables	**ADF t-test**	**ADF z-test**	**Joint Test**	**Lags**
Oil Price	-7.85**	-127.02**	30.82	1
Deficit *1	-7.455**	87.5536	27.9739**	6
Price Level	-1.94	-5.99	2.22	2
M2	-4.9283**	-40.5427**	12.1452**	0
MP2	-5.4739**	-47.95**	15.01**	0
Real GNP	-7.04**	-69.92**	24.79**	0
Exchange Rate	-8.26**	-85.77**	34.15**	0

Note:
*1 Deficit is the ratio of the logarithm of the real government deficit to government debt subtracted from one.
Model Selection Criteria: Minimum AIC / Minimum BIC

Choosing the optimal lag length for the ADF regression between 0 and 20 lags.

** significant at 1%; * significant at 5% # significant at 10%

Table 4-3

Estimated Contemporaneous Coefficients for The U.S. Revisited

Table 4-3 Restricted Karras models **m = M2 (restricted)**

$$z_t^o = u_t^o$$

$$z_t^f = a_1 z_t^y + u_t^f$$

$$z_t^{ys} = a_2 z_t^o + a_3 z_t^p + u_t^{ys}$$

$$z_t^m = a_4 z_t^f + a_5 z_t^p + a_6 z_t^y + a_7 z_t^{ex} + u_t^m$$

$$z_t^{yd} = a_8 z_t^o + a_9 z_t^f + a_{10}(z_t^m - z_t^p) + u_t^{yd}$$

$$z_t^{ex} = a_{11} z_t^o + a_{12} z_t^f + a_{13} z_t^p + a_{14} z_t^m + a_{15} z_t^y + u_t^{ex}$$

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
coefficients	0.00000	-0.00293	4.973411	0.198507	-2.06821	-0.67032	-0.05083	0.004143	-0.1718	1.361685	0.033977	-0.48818	1.05601	-0.33083	0.011087
standard errors	0.00000	0.013874	17.4118	0.14525	0.569574	0.158027	0.181175	0.008913	0.185769	0.430923	0.016426	0.327219	1.090155	0.357069	0.311829
t-stat	0.00000	-0.21096	0.28563	1.36666	-3.63116	-4.2418	-0.28056	0.4648	-0.92479	3.15993	2.06849	-1.4919	0.96868	-0.92651	0.03555
significance level	0.00000	0.833334	0.775726	0.174738	0.000443	4.89E-05	0.779617	0.643056	0.357238	0.002072	0.041148	0.138842	0.335019	0.356391	0.971708

Table 4-4

Variance Decompositions for The U.S. Revisited

Percentage of OIL Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**AD**	**Monetary**	**Exchange**
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of deficit Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	0.09%	94.33%	0.00%	2.86%	2.15%	0.58%
4	3.83%	73.50%	1.41%	11.84%	2.84%	6.59%
8	3.78%	69.94%	1.83%	14.86%	3.49%	6.09%
20	4.00%	68.37%	2.14%	16.29%	4.03%	5.19%

Percentage of Price Level Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	1.01%	4.10%	53.11%	34.17%	6.40%	1.20%
4	2.49%	4.37%	37.61%	39.92%	5.48%	10.13%
8	1.84%	3.00%	25.13%	51.05%	4.78%	14.20%
20	1.75%	2.31%	17.07%	54.44%	12.35%	12.08%

Percentage of Monetary (M2) Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	0.70%	2.87%	2.27%	5.22%	87.38%	1.56%
4	8.35%	2.41%	3.79%	6.20%	75.18%	4.07%
8	8.43%	2.41%	3.52%	7.84%	73.27%	4.53%
20	7.96%	2.55%	3.31%	13.25%	68.29%	4.64%

Percentage of Real GNP Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	4.79%	1.00%	27.24%	58.31%	8.30%	0.36%
4	4.65%	1.29%	24.56%	55.16%	13.71%	0.64%
8	4.73%	1.35%	24.16%	54.51%	14.09%	1.17%
20	4.72%	1.51%	23.89%	54.39%	14.07%	1.43%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	4.68%	2.69%	1.93%	2.01%	2.56%	86.14%
4	7.92%	2.90%	2.55%	1.91%	2.63%	82.10%
8	7.75%	3.21%	3.09%	2.21%	3.14%	80.60%
20	7.66%	4.01%	3.12%	2.69%	3.48%	79.05%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	13.49%	0.80%	0.22%	0.65%	0.69%	2.24%
4	13.49%	1.08%	0.29%	0.75%	0.73%	2.37%
8	13.49%	1.32%	0.36%	0.79%	0.74%	2.40%
20	13.49%	1.72%	0.44%	0.82%	0.75%	2.43%

Table 5-1

Stationarity Test for Taiwan

Using Logarithm Data from 82:1 to 2000:4 with First Difference				
Testing the Null Hypothesis of a Unit Root in				
Variables	**ADF t-test**	**ADF z-test**	**Joint Test**	**Lags**
Oil Price	-6.92**	-99.93**	23.96**	1
Deficit*1	-12.46**	-101.31**	77.65**	0
Price Level	-9.51**	-83.67**	45.27**	0
M2	-3.38*	-20.76**	5.81*	0
MP2	-5.79**	-47.88**	16.83**	0
Real GNP	-9.33**	-82.32**	43.56**	0
Exchange Rate	-6.35**	-52.81**	20.17**	0

Note:

*1 Deficit is the ratio of the logarithm of the real government deficit to government debt subtracted from one.

Model Selection Criteria: Minimum AIC / Minimum BIC

Choosing the optimal lag length for the ADF regression between 0 and 20 lags.

** significant at 1%; * significant at 5% # significant at 10%

Table 5-2
Estimated Contemporaneous Coefficients for Taiwan

Table 5-2 (A) Restricted Karras models m = M2 (restricted)

$$z_t^{o} = u_t^{o}$$

$$z_t^{f} = a_1 z_t^{y} + u_t^{f}$$

$$z_t^{ys} = a_2 z_t^{o} + a_3 z_t^{p} + u_t^{ys}$$

$$z_t^{m} = a_4 z_t^{f} + a_5 z_t^{p} + a_6 z_t^{y} + a_7 z_t^{ex} + u_t^{m}$$

$$z_t^{yd} = a_8 z_t^{o} + a_9 z_t^{f} + a_{10}(z_t^{m} - z_t^{p}) + u_t^{yd}$$

$$z_t^{ex} = a_{11} z_t^{o} + a_{12} z_t^{f} + a_{13} z_t^{p} + a_{14} z_t^{m} + a_{15} z_t^{y} + u_t^{ex}$$

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
coefficients	0.00000	0.00000	-1.14457	0.58893	-2.59451	1.60575	-4.22029	-0.00581	0.02051	-1.34129	-0.62276	1.49358	-16.19067	-19.69407	7.44990
standard errors	0.00000	0.01401	0.90416	1.93672	7.16804	4.95859	15.43075	0.02167	0.02964	0.44949	0.54455	1.13806	13.04545	16.07369	6.15867
t-stat	0.00000	-0.00019	-1.26589	0.30408	-0.36196	0.32383	-0.27350	-0.26829	0.69205	-2.98401	-1.14363	1.31239	-1.24110	-1.22524	1.20966
significance level	0.00000	0.99985	0.20975	0.76199	0.71851	0.74706	0.78530	0.78928	0.49123	0.00393	0.25685	0.19387	0.21890	0.22478	0.23066

Table 5-2

Estimated Contemporaneous Coefficients for Taiwan

Table 5-2 (B) Original Karras models   m = M2 (unrestricted)

$$z_t^{o} = u_t^{o}$$
$$z_t^{f} = a_1 z_t^{y} + u_t^{f}$$
$$z_t^{ys} = a_2 z_t^{o} + a_3 z_t^{p} + u_t^{ys}$$
$$z_t^{m} = a_4 z_t^{f} + a_5 z_t^{p} + a_6 z_t^{y} + u_t^{m}$$
$$z_t^{yd} = a_7 z_t^{o} + a_8 z_t^{f} + a_9 z_t^{p} + a_{10} z_t^{m} + u_t^{yd}$$
$$z_t^{ex} = a_{11} z_t^{o} + a_{12} z_t^{f} + a_{13} z_t^{p} + a_{14} z_t^{m} + a_{15} z_t^{y} + u_t^{ex}$$

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
coefficients	16.30686	-0.03488	-6.28993	-0.07255	0.07530	-0.68010	0.09685	-0.29482	1.34352	2.85392	-0.01343	0.16875	-0.95068	-0.65656	0.53294
standard errors	26.25227	0.05469	3.95892	0.07971	0.32850	0.49088	0.04013	0.09705	0.64396	0.97971	0.02921	0.04166	0.45126	0.40310	0.32231
t-stat	0.62116	-0.63779	-1.58880	-0.91021	0.22921	-1.38549	2.41328	-3.03771	2.08636	2.91302	-0.45974	4.05096	-2.10672	-1.62880	1.65351
significance level	0.53648	0.52569	0.11661	0.36588	0.81938	0.17037	0.01851	0.00338	0.04070	0.00484	0.64719	0.00013	0.03889	0.10805	0.10291

Table 5-2
Estimated Contemporaneous Coefficients for Taiwan

Table 5-2 (C) Choleski Model

$$z_t^{\,o} = v_t^o$$
$$z_t^{\,f} = r_1 z_t^o + v_t^f$$
$$z_t^{\,p} = r_2 z_t^o + r_3 z_t^f + v_t^p$$
$$z_t^{\,m} = r_4 z_t^o + r_5 z_t^f + r_6 z_t^p + v_t^m$$
$$z_t^{\,y} = r_7 z_t^o + r_8 z_t^f + r_9 z_t^p + r_{10} z_t^m + v_t^y$$
$$z_t^{\,ex} = r_{11} z_t^o + r_{12} z_t^f + r_{13} z_t^p + r_{14} z_t^m + r_{15} z_t^y + v_t^{ex}$$

	r1	r2	r3	r4	r5	r6	r7	r8	r9	r10	r11	r12	r13	r14	r15
coefficients	16.30686	-0.00994	0.02502	-0.02293	0.04485	-0.33874	0.03152	-0.16350	-0.16277	0.27988	-0.01343	0.16875	-0.95068	-0.65656	0.53294
standard errors	26.25227	0.00768	0.01544	0.00837	0.01655	0.13094	0.01807	0.03703	0.27561	0.24726	0.02921	0.04166	0.45126	0.40310	0.32231
t-stat	0.62116	-1.29436	1.62014	-2.73883	2.70926	-2.58691	1.74438	-4.41541	-0.59060	1.13193	-0.45974	4.05096	-2.10672	-1.62880	1.65351
significance level	0.53648	0.19979	0.10970	0.00784	0.00850	0.01180	0.08561	0.00004	0.55675	0.26164	0.64719	0.00013	0.03889	0.10805	0.10291

Table 5-3

Variance Decompositions for Taiwan (Restricted Karras Model)

Percentage of OIL Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of Deficit Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	0.0%	96.3%	0.1%	0.4%	3.2%	0.0%
4	2.6%	74.8%	5.2%	11.2%	2.8%	3.5%
8	5.7%	68.1%	8.8%	11.2%	2.9%	3.4%
20	12.6%	59.7%	11.7%	10.3%	2.6%	3.1%

Percentage of Price Level Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	28.3%	0.4%	61.4%	2.5%	3.2%	4.3%
4	31.0%	0.5%	59.0%	2.5%	2.6%	4.5%
8	35.3%	0.8%	54.4%	3.2%	2.5%	4.0%
20	37.7%	0.9%	51.1%	3.9%	2.5%	3.9%

Percentage of Monetary (M2) Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	10.0%	15.3%	1.7%	7.6%	35.8%	29.4%
4	20.9%	13.6%	2.3%	6.4%	28.5%	28.3%
8	20.5%	13.4%	2.1%	6.1%	28.3%	29.6%
20	19.9%	13.5%	2.7%	6.5%	27.7%	29.7%

Percentage of Real GNP Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	4.0%	7.7%	1.5%	8.4%	56.6%	21.9%
4	5.4%	7.3%	11.8%	10.7%	44.6%	20.2%
8	13.4%	7.2%	14.0%	9.8%	36.9%	18.7%
20	13.9%	6.8%	17.9%	9.9%	33.7%	17.8%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	1.5%	20.7%	2.8%	73.0%	2.0%	0.1%
4	9.1%	16.3%	5.0%	60.1%	9.4%	0.1%
8	11.9%	17.2%	4.9%	56.0%	9.0%	1.0%
20	11.9%	17.3%	5.2%	55.3%	9.1%	1.2%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	14.4%	9.1%	0.8%	0.9%	0.9%	2.7%
4	14.4%	10.7%	0.9%	1.2%	1.0%	3.1%
8	14.4%	11.3%	1.0%	1.4%	1.2%	3.3%
20	14.4%	12.1%	1.1%	1.5%	1.2%	3.3%

Table 5-4

Variance Decompositions for Taiwan (Unrestricted Karras Model)

Percentage of OIL Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of Deficit Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	4.2%	30.4%	2.5%	49.6%	13.2%	0.2%
4	5.3%	24.1%	7.4%	36.4%	14.5%	12.3%
8	7.0%	23.3%	10.4%	34.1%	13.3%	11.9%
20	13.0%	20.6%	13.5%	30.1%	11.9%	10.8%

Percentage of Price Level Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	24.0%	2.5%	66.3%	0.7%	2.0%	4.4%
4	26.2%	2.4%	64.2%	1.0%	3.0%	3.3%
8	30.3%	2.5%	59.5%	1.1%	3.0%	3.6%
20	33.0%	2.4%	55.8%	1.4%	3.4%	3.9%

Percentage of Monetary (M2) Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	9.4%	3.7%	1.6%	65.6%	19.1%	0.7%
4	26.1%	4.2%	2.1%	49.5%	17.4%	0.7%
8	28.1%	3.9%	1.8%	48.3%	17.2%	0.7%
20	28.6%	3.9%	2.2%	47.6%	17.0%	0.7%

Percentage of Real GNP Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	1.6%	74.4%	1.0%	15.7%	4.9%	2.5%
4	6.6%	56.1%	11.0%	13.7%	8.7%	3.9%
8	16.2%	44.8%	13.6%	13.0%	8.4%	4.1%
20	16.8%	39.8%	17.7%	12.9%	8.5%	4.2%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	5.3%	0.8%	1.0%	15.3%	12.6%	65.1%
4	10.9%	2.2%	4.2%	18.9%	10.3%	53.4%
8	15.7%	2.3%	4.1%	18.7%	11.0%	48.2%
20	15.8%	2.3%	4.6%	18.9%	10.9%	47.5%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	14.4%	9.1%	0.8%	0.9%	0.9%	2.7%
4	14.4%	10.7%	0.9%	1.2%	1.0%	3.1%
8	14.4%	11.3%	1.0%	1.4%	1.2%	3.3%
20	14.4%	12.1%	1.1%	1.5%	1.2%	3.3%

Table 5-5

Variance Decompositions for Taiwan (Choleski Model)

Percentage of OIL Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of Deficit Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	0.1%	92.2%	0.1%	0.3%	6.8%	0.4%
4	1.8%	72.9%	5.0%	10.9%	5.1%	4.3%
8	4.4%	67.2%	8.6%	10.9%	4.9%	4.1%
20	10.5%	59.5%	11.5%	10.1%	4.5%	3.9%

Percentage of Price Level Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	28.1%	0.9%	62.5%	2.5%	2.2%	3.9%
4	29.2%	0.9%	61.1%	2.5%	1.9%	4.4%
8	33.1%	1.2%	56.6%	3.2%	1.9%	4.0%
20	35.3%	1.3%	53.3%	4.0%	1.9%	4.1%

Percentage of Monetary (M2) Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	9.5%	12.2%	1.9%	7.3%	36.7%	32.4%
4	20.2%	11.6%	2.5%	6.1%	28.8%	30.8%
8	20.3%	11.3%	2.2%	5.7%	28.6%	31.9%
20	20.0%	11.4%	2.8%	6.0%	28.1%	31.7%

Percentage of Real GNP Variance Explained by Shock to						
Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	3.5%	22.5%	1.1%	6.3%	51.9%	14.8%
4	5.3%	18.7%	11.1%	9.0%	40.7%	15.2%
8	12.8%	16.5%	13.5%	8.4%	34.1%	14.8%
20	13.1%	15.1%	17.4%	8.7%	31.3%	14.5%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	1.8%	17.7%	2.5%	74.7%	3.2%	0.0%
4	9.1%	13.9%	4.9%	61.7%	10.1%	0.3%
8	12.1%	14.5%	4.9%	57.4%	9.9%	1.3%
20	12.1%	14.5%	5.2%	56.7%	10.0%	1.4%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	14.4%	9.3%	0.8%	0.9%	0.9%	2.9%
4	14.4%	11.0%	0.9%	1.2%	1.1%	3.3%
8	14.4%	11.7%	1.0%	1.3%	1.2%	3.4%
20	14.4%	12.4%	1.1%	1.4%	1.3%	3.5%

Table 6-1

Stationarity Test for Japan

Using Logarithm data from 1984:01 to 2001:02 with First Difference				
Testing the Null Hypothesis of a Unit Root in				
Variables	**ADF t-test**	**ADF z-test**	**Joint Test**	**Lags**
Oil Price	-4.92**	-292.93**	12.12	3
Deficit *1	-11.92**	-96.37**	71.22**	0
Price Level	-8.60**	-74.37**	37.08**	0
M2	-1.55	-6.57	1.42	1
MP2	-7.28**	-61.92**	26.58**	0
Real GNI	-6.47**	-59.47**	21.03**	0
Exchange Rate	-6.57**	-54.38**	21.62**	0

Note:
*1 Deficit is the ratio of the logarithm of the real government deficit to government debt subtracted from one.
Model Selection Criteria: Minimum AIC / Minimum BIC

Choosing the optimal lag length for the ADF regression between 0 and 20 lags.

** significant at 1%; * significant at 5% # significant at 10%

Table 6-2

Estimated Contemporaneous Coefficients for Japan

Table 6-2 Restricted Karras models m=M2 (restricted:)

$$z_t^{o} = u_t^{o}$$

$$z_t^{f} = a_1 z_t^{y} + u_t^{f}$$

$$z_t^{ys} = a_2 z_t^{o} + a_3 z_t^{p} + u_t^{ys}$$

$$z_t^{m} = a_4 z_t^{f} + a_5 z_t^{p} + a_6 z_t^{y} + a_7 z_t^{ex} + u_t^{m}$$

$$z_t^{yd} = a_8 z_t^{o} + a_9 z_t^{f} + a_{10} (z_t^{m} - z_t^{p}) + u_t^{yd}$$

$$z_t^{ex} = a_{11} z_t^{o} + a_{12} z_t^{f} + a_{13} z_t^{p} + a_{14} z_t^{m} + a_{15} z_t^{y} + u_t^{ex}$$

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
coefficients	0.00000	0.017262	-1.94514	0.014388	-0.37034	0.054245	0.637444	-1.17674	-0.22269	-2.903	0.025775	-0.83427	-1.66339	0.357827	-1.45846
standard errors	0.00000	0.016883	1.111397	0.008172	0.11661	0.130687	0.191055	1.260809	0.266046	3.177646	0.030122	0.423224	0.480834	0.385061	0.966747
t-stat	0.00000	1.02244	-1.75017	1.76064	-3.17592	0.41507	3.33644	-0.93333	-0.83702	-0.91357	0.85567	-1.97123	-3.45939	0.92927	-1.50863
significance level	0.00000	0.310422	0.084881	0.083231	0.002328	0.679521	0.001438	0.354215	0.405747	0.364426	0.395529	0.053239	0.000994	0.356411	0.136557

Table 6-3

Variance Decompositions for Japan (Restricted Karras Model)

Percentage of OIL Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**AD**	**Monetary**	**Exchange**
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of Deficit Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	2.4%	92.8%	1.0%	0.3%	3.4%	0.1%
4	13.0%	63.2%	11.6%	3.6%	7.3%	1.5%
8	15.4%	55.6%	10.1%	7.5%	9.7%	1.8%
20	17.1%	52.0%	10.6%	8.6%	9.7%	2.0%

Percentage of Price Level Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	5.9%	0.7%	87.2%	3.6%	1.5%	1.1%
4	14.9%	4.3%	62.1%	13.6%	1.9%	3.2%
8	19.0%	5.2%	53.5%	15.4%	3.3%	3.5%
20	28.3%	6.1%	45.0%	13.8%	3.5%	3.3%

Percentage of Monetary (M2) Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**AD**	**Monetary**	**Exchange**
1	9.1%	5.0%	6.5%	34.9%	39.2%	5.4%
4	46.5%	4.0%	5.7%	18.4%	16.9%	8.6%
8	47.5%	3.9%	10.0%	16.8%	14.5%	7.3%
20	52.3%	3.1%	12.9%	13.9%	11.8%	6.0%

Percentage of Real GNI Variance Explained by Shock to						
Horizon (Quarters)	**Oil**	**Deficit**	**AS**	**Monetary**	**AD**	**Exchange**
1	6.5%	11.9%	4.5%	35.6%	37.6%	3.8%
4	24.6%	12.9%	8.2%	24.2%	25.9%	4.1%
8	24.5%	14.0%	12.7%	23.7%	20.9%	4.2%
20	32.4%	10.7%	16.5%	19.6%	16.7%	4.2%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	4.6%	5.4%	13.3%	6.8%	4.2%	65.8%
4	17.7%	11.1%	12.5%	12.1%	3.0%	43.5%
8	17.2%	14.5%	15.0%	13.4%	4.2%	35.8%
20	17.0%	14.6%	16.7%	14.6%	4.1%	32.9%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	14.5%	1.0%	0.8%	0.9%	0.4%	3.1%
4	14.5%	1.2%	0.9%	1.6%	0.5%	3.9%
8	14.5%	1.3%	1.0%	1.8%	0.6%	4.4%
20	14.5%	1.4%	1.2%	2.2%	0.7%	4.6%

Table 7-1

Stationarity Test for Korea

Using Logarithm data from 1982:1 to 2000:2 with First Difference				
TESTING THE NULL HYPOTHESIS OF A UNIT ROOT IN				
Variables	**ADF t-test**	**ADF z-test**	**Joint Test**	**Lags**
Oil Price	-7.09**	-114.89**	25.22	1
Deficit *1	-9.07**	788.56	41.19**	2
Price Level	-8.15**	-69.47**	33.32**	1
M2	-7.54**	-66.65**	28.47**	0
MP2	-3.69**	-29.38**	6.81**	1
Real GNI	-10.46**	17.65	60.25**	13
Exchange Rate	-11.53**	-96.27**	66.56**	0

Note:

*1 Deficit is the ratio of the logarithm of the real government deficit to government debt subtracted from one.

Model Selection Criteria: Minimum AIC / Minimum BIC

Choosing the optimal lag length for the ADF regression between 0 and 20 lags.

** significant at 1%; * significant at 5% # significant at 10%

Table 7-2

Estimated Contemporaneous Coefficients for Korea

Table 7-2 Restricted Karras model   m=M2 (restricted:)

$$z_t^o = u_t^o$$

$$z_t^f = a_1 z_t^y + u_t^f$$

$$z_t^{ys} = a_2 z_t^o + a_3 z_t^p + u_t^{ys}$$

$$z_t^m = a_4 z_t^f + a_5 z_t^p + a_6 z_t^y + a_7 z_t^{ex} + u_t^m$$

$$z_t^{yd} = a_8 z_t^o + a_9 z_t^f + a_{10}(z_t^m - z_t^p) + u_t^{yd}$$

$$z_t^{ex} = a_{11} z_t^o + a_{12} z_t^f + a_{13} z_t^p + a_{14} z_t^m + a_{15} z_t^y + u_t^{ex}$$

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
coefficients	0.0000	0.0581	5.8704	-0.0381	-1.6369	-0.0388	0.2183	-3.3726	-2.3012	64.0902	-0.1985	0.0345	-2.5655	-2.2471	-0.0493
standard errors	0.0000	0.6511	17.7944	0.0498	0.6303	0.0197	0.3062	2.3630	1.9821	36.7007	0.1017	0.1046	0.8969	0.7060	0.0385
t-stat	0.0000	0.0892	0.3299	-0.7656	-2.5971	-1.9708	0.7128	-1.4273	-1.1610	1.7463	-1.9528	0.3298	-2.8605	-3.1830	-1.2798
significance level	0.0000	0.9292	0.7425	0.4467	0.0116	0.0529	0.4785	0.1581	0.2498	0.0853	0.0551	0.7427	0.0057	0.0022	0.2052

Table 7-3

Variance Decompositions For Korea (Restricted Karras Model)

Percentage of OIL Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
4	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
8	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)
20	100.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)

Percentage of deficit Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	2.2%	89.8%	5.0%	1.0%	0.4%	1.6%
4	5.7%	78.6%	5.4%	4.7%	1.8%	3.9%
8	8.2%	75.9%	5.2%	4.6%	2.1%	3.9%
20	8.7%	75.0%	5.2%	4.7%	2.2%	4.2%

Percentage of Price Level Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	9.7%	3.9%	60.0%	2.5%	0.1%	23.9%
4	21.3%	10.9%	45.5%	2.8%	1.2%	18.4%
8	24.9%	11.1%	42.0%	2.6%	2.3%	17.2%
20	24.7%	11.2%	41.7%	2.6%	2.7%	17.0%

Percentage of Monetary (M2) Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	AD	Monetary	Exchange
1	0.4%	10.7%	4.9%	0.9%	82.8%	0.3%
4	4.3%	8.9%	10.2%	2.5%	69.5%	4.5%
8	6.2%	8.2%	10.9%	2.7%	65.4%	6.5%
20	7.9%	8.5%	10.8%	2.7%	63.4%	6.7%

Percentage of Real GNI Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	1.4%	0.8%	0.4%	90.6%	2.8%	4.0%
4	4.4%	3.7%	0.6%	82.2%	5.3%	3.7%
8	4.8%	4.0%	0.9%	79.9%	6.3%	4.1%
20	5.1%	4.0%	0.9%	79.4%	6.3%	4.3%

Percentage of Exchange Rate Variance Explained by Shock to

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	6.0%	8.9%	0.1%	4.8%	9.6%	70.6%
4	16.1%	7.8%	0.8%	4.6%	12.9%	57.8%
8	16.9%	9.6%	1.0%	4.8%	12.9%	54.9%
20	17.3%	9.6%	1.0%	5.1%	12.8%	54.2%

Forecast Mean Squared Error

Horizon (Quarters)	Oil	Deficit	AS	Monetary	AD	Exchange
1	14.0%	12.7%	1.7%	1.7%	34.5%	8.6%
4	14.0%	14.2%	1.9%	2.1%	36.5%	9.6%
8	14.0%	14.8%	2.0%	2.2%	37.5%	9.9%
20	14.0%	14.9%	2.0%	2.2%	37.6%	9.9%

APPENDIX B

Figure 4-1 The Case of U.S. (Restricted Karras Model)

Figure 4-1 (a) Accumulated Response of Output to

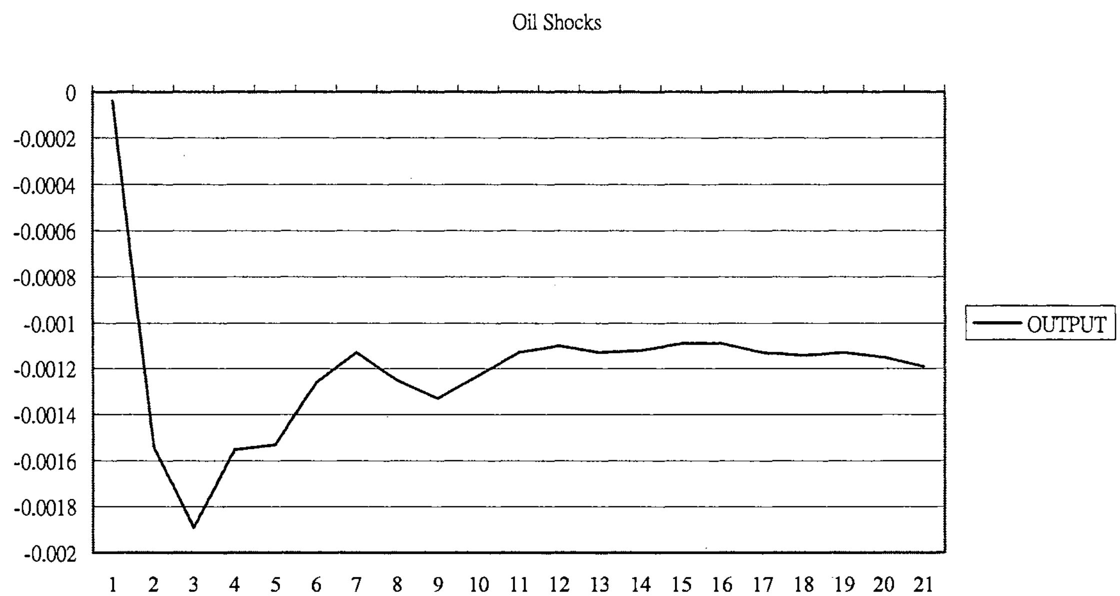


Figure 4-1 (b) Accumulated Response of Output to

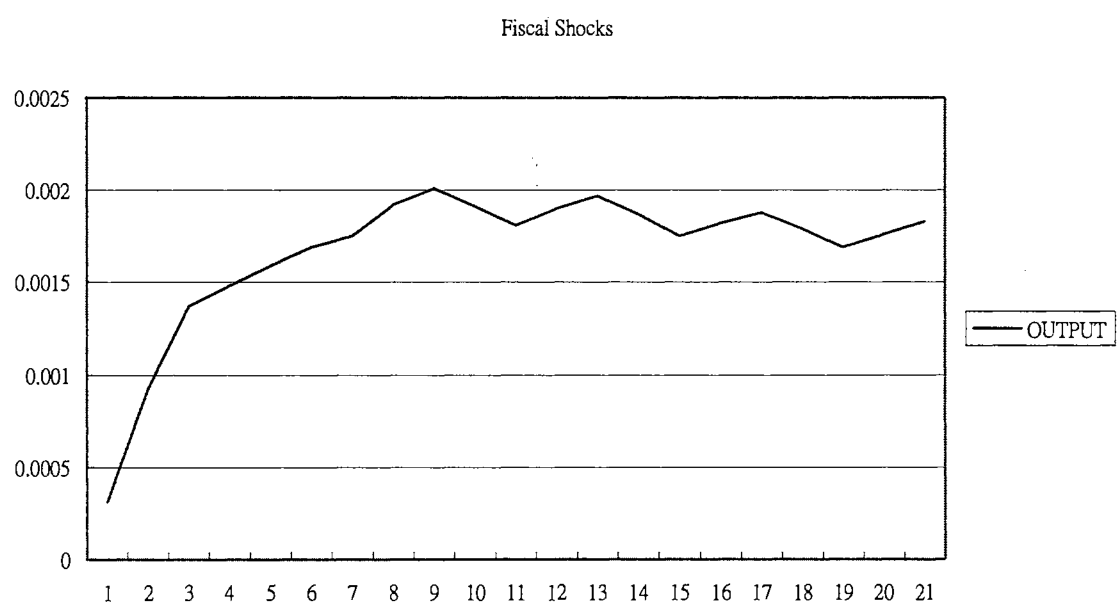


Figure 4-1 (c) Accumulated Response of Output to

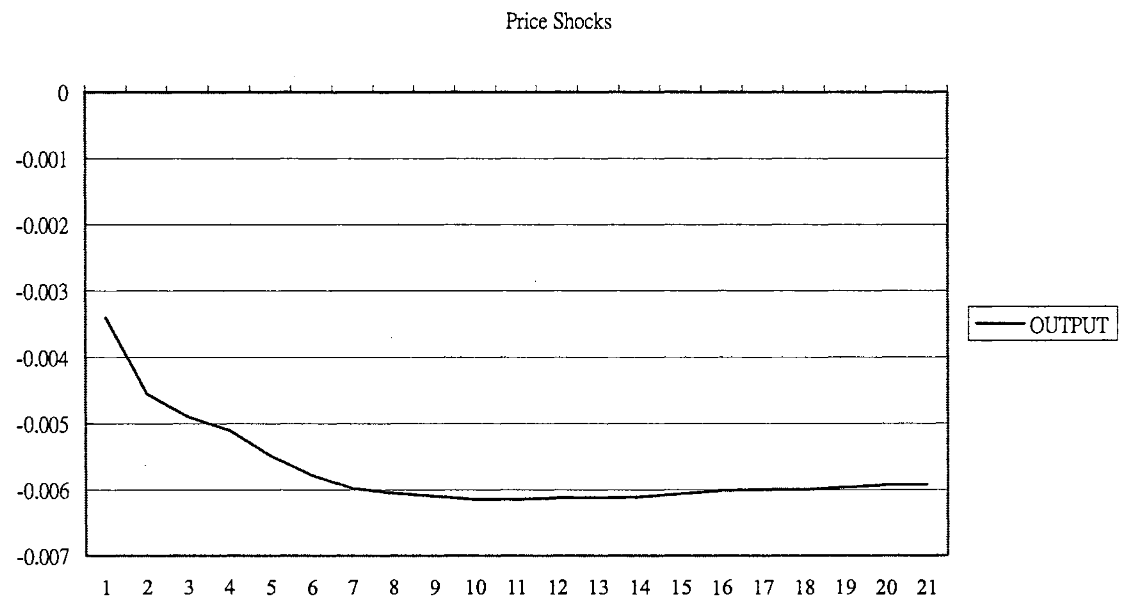


Figure 4-1 (d) Accumulated Response of Output to

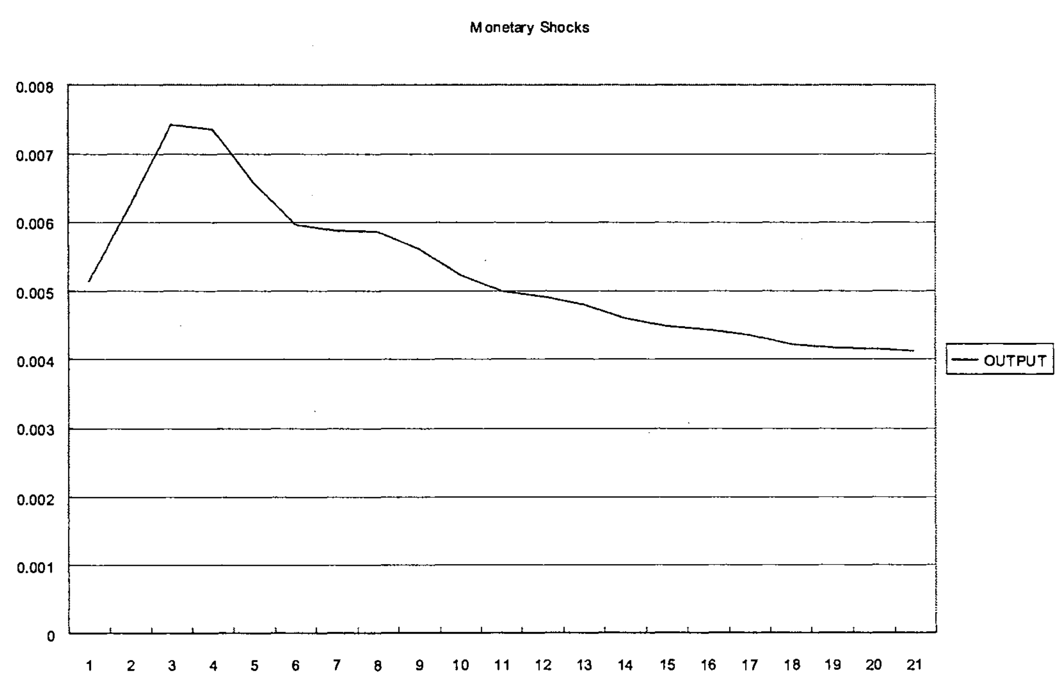


Figure 4-1 (e) Accumulated Response of Output to

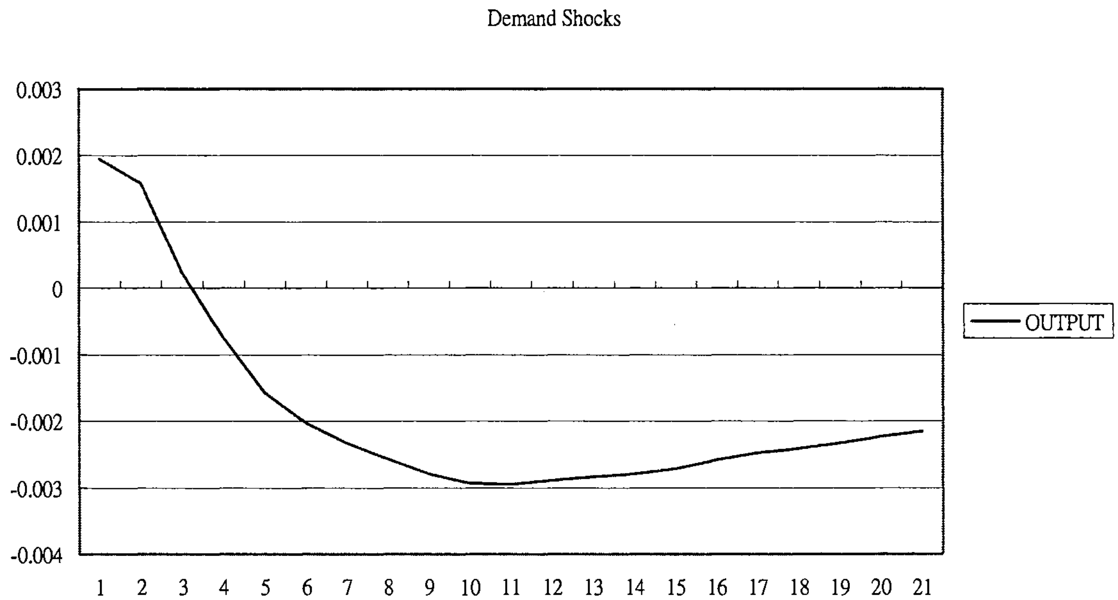


Figure 4-1 (f) Accumulated Response of Output to

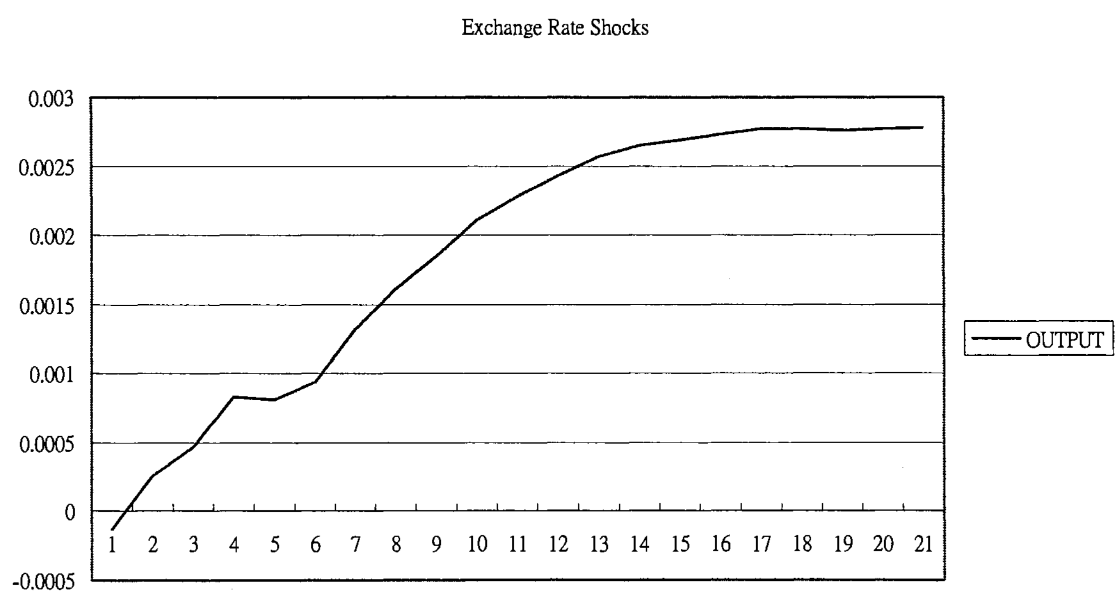


Figure 4-2 The Case of U.S. (Restricted Karras Model)

Figure 4-2 (a) Accumulated Response of Price Level to

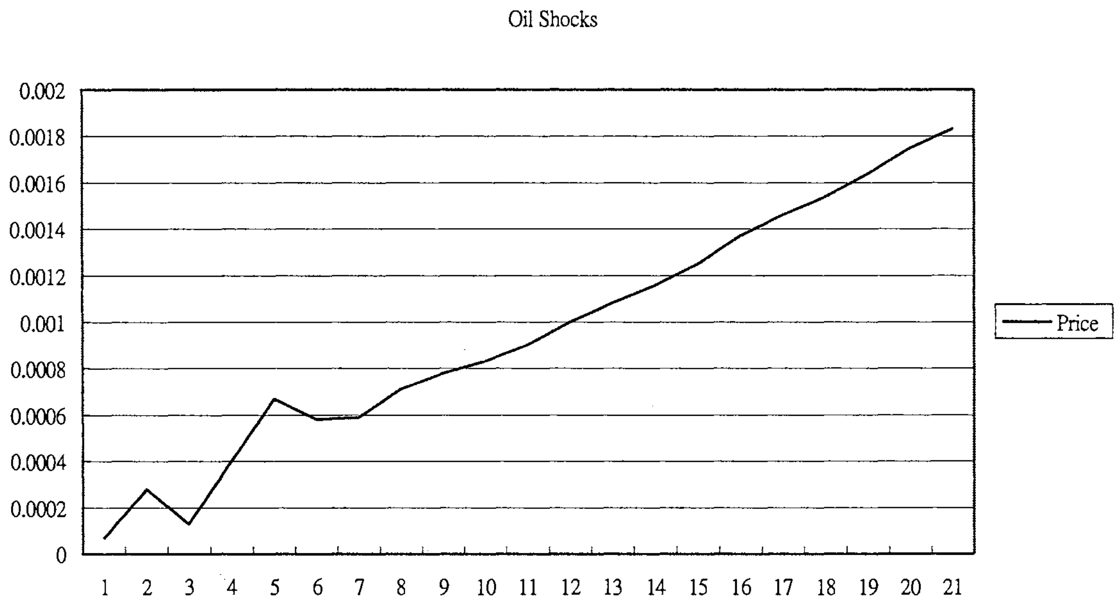


Figure 4-2 (b) Accumulated Response of Price Level to

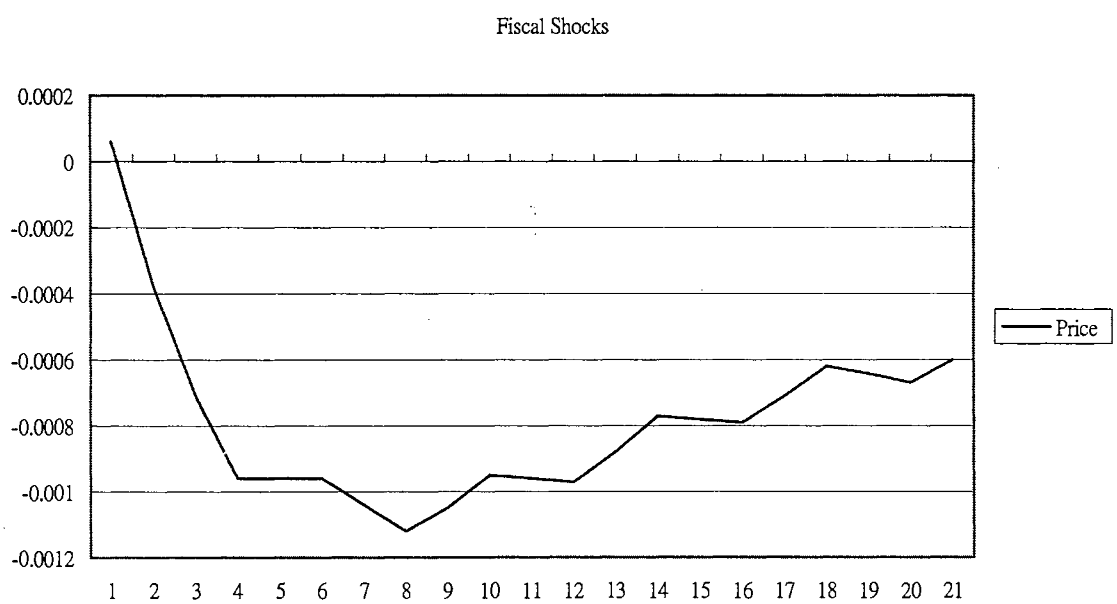


Figure 4-2 (c) Accumulated Response of Price Level to

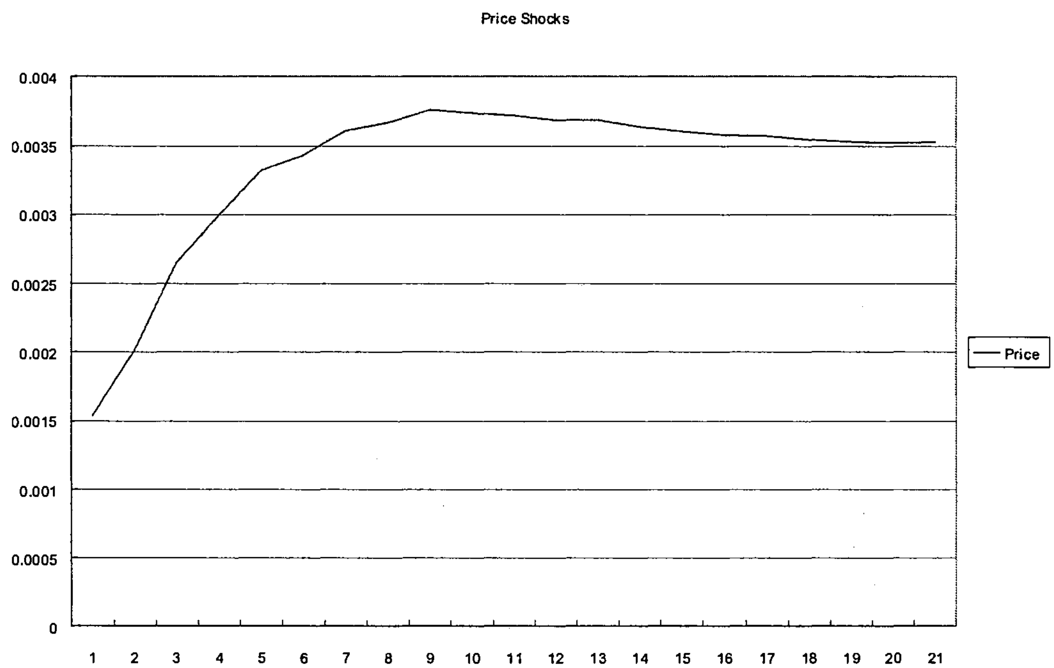


Figure 4-2 (d) Accumulated Response of Price Level to

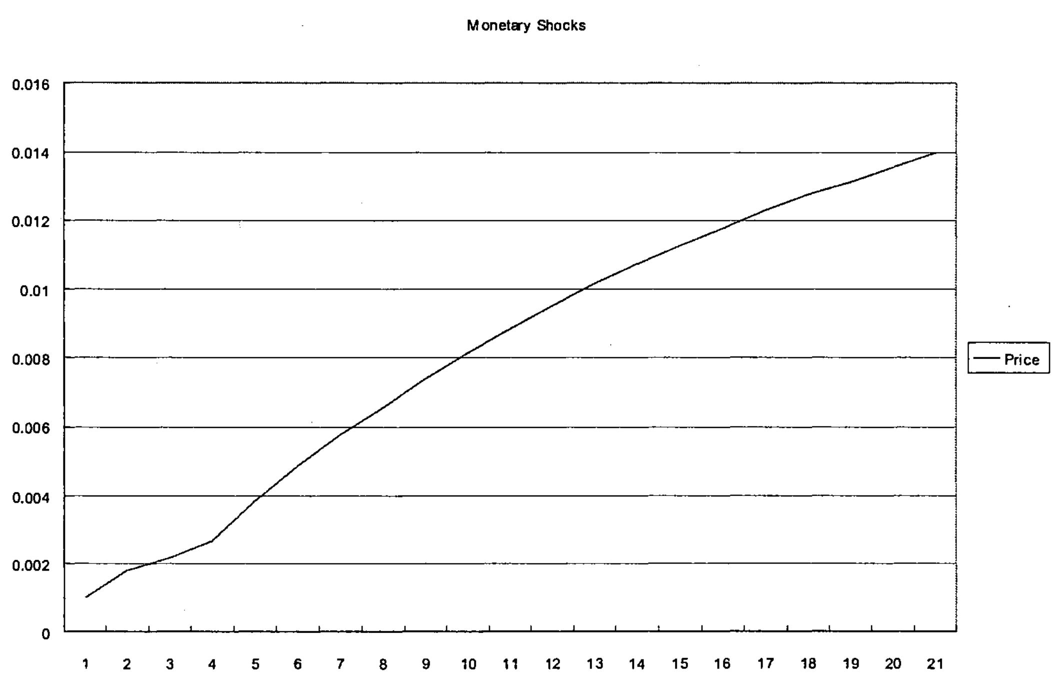


Figure 4-2 (e) Accumulated Response of Price Level to

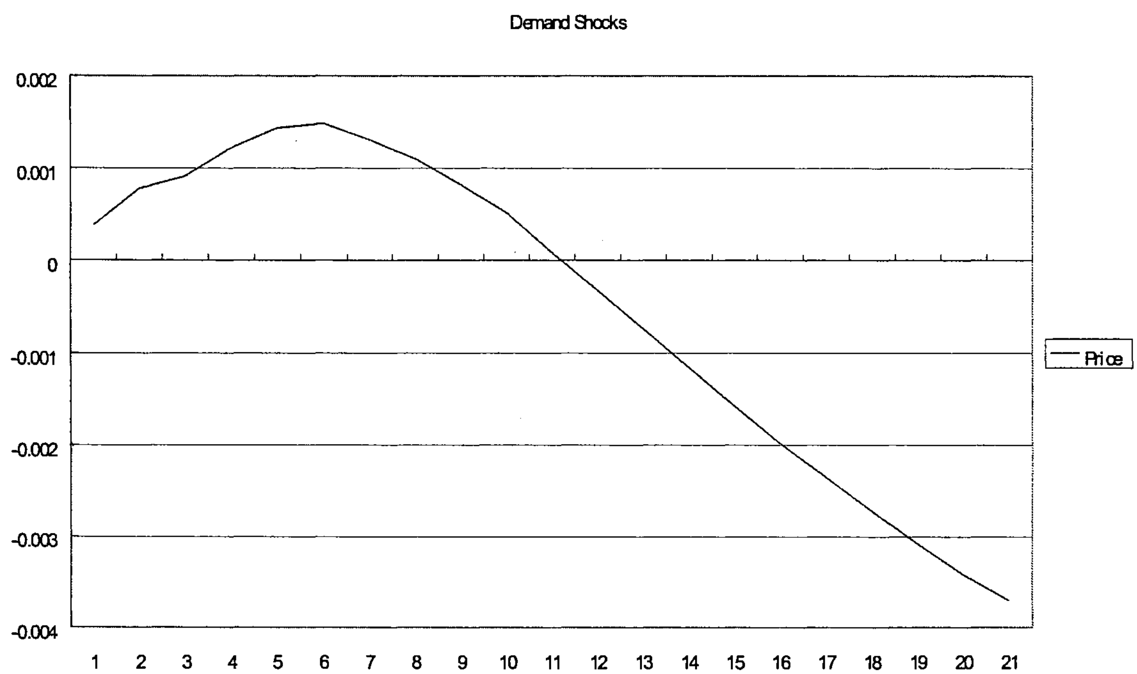


Figure 4-2 (f) Accumulated Response of Price Level to

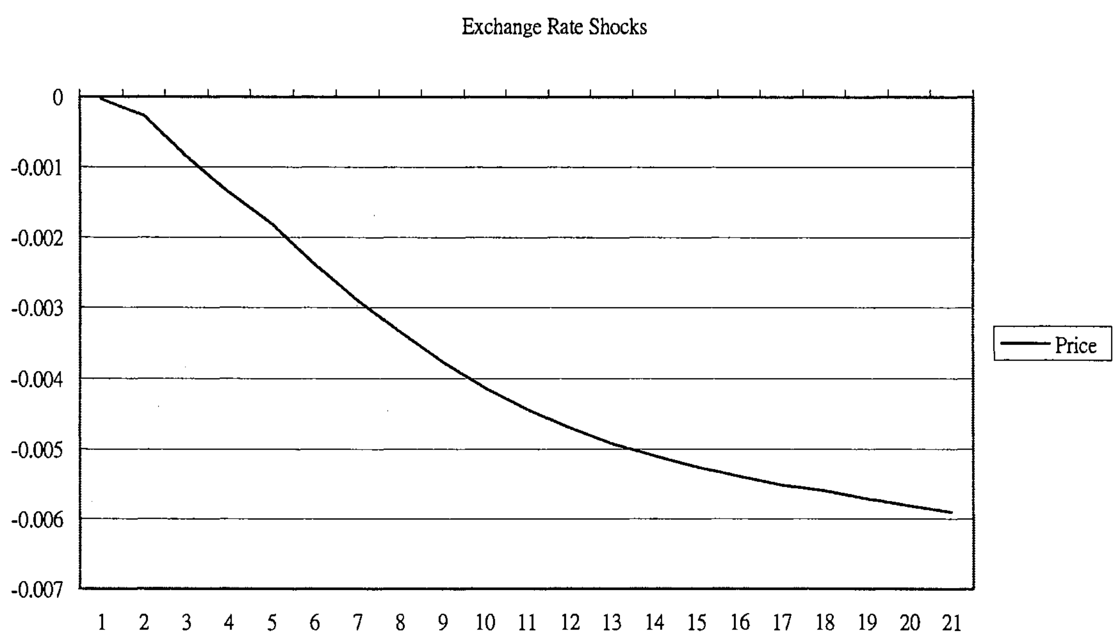


Figure 4-3 The Case of U.S. (Restricted Karras Model)

Figure 4-3 (a) Accumulated Response of Exchange Rate to

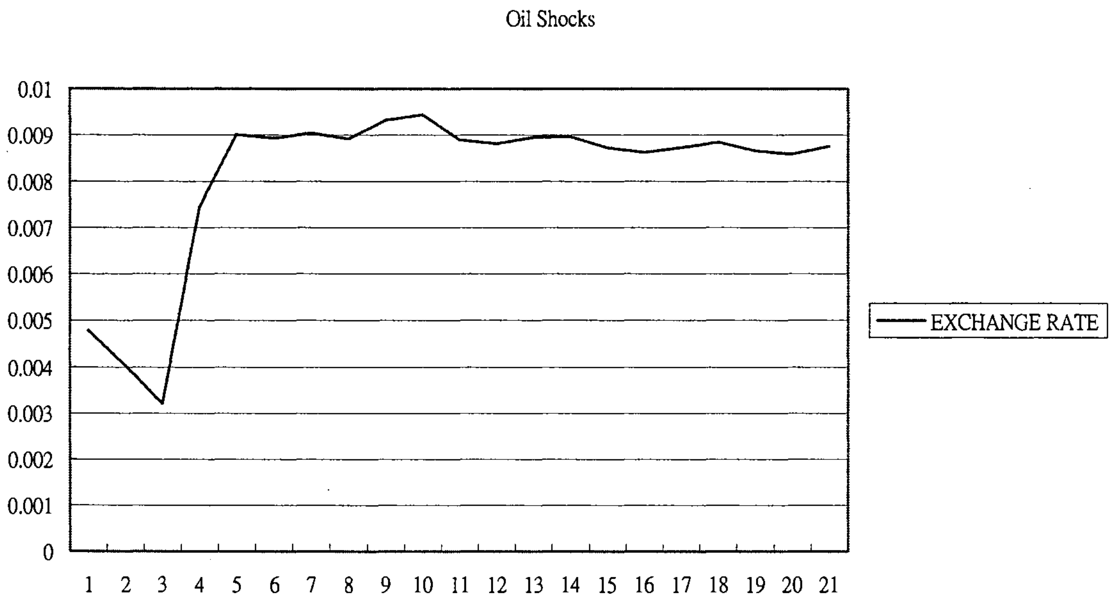


Figure 4-3 (b) Accumulated Response of Exchange Rate to

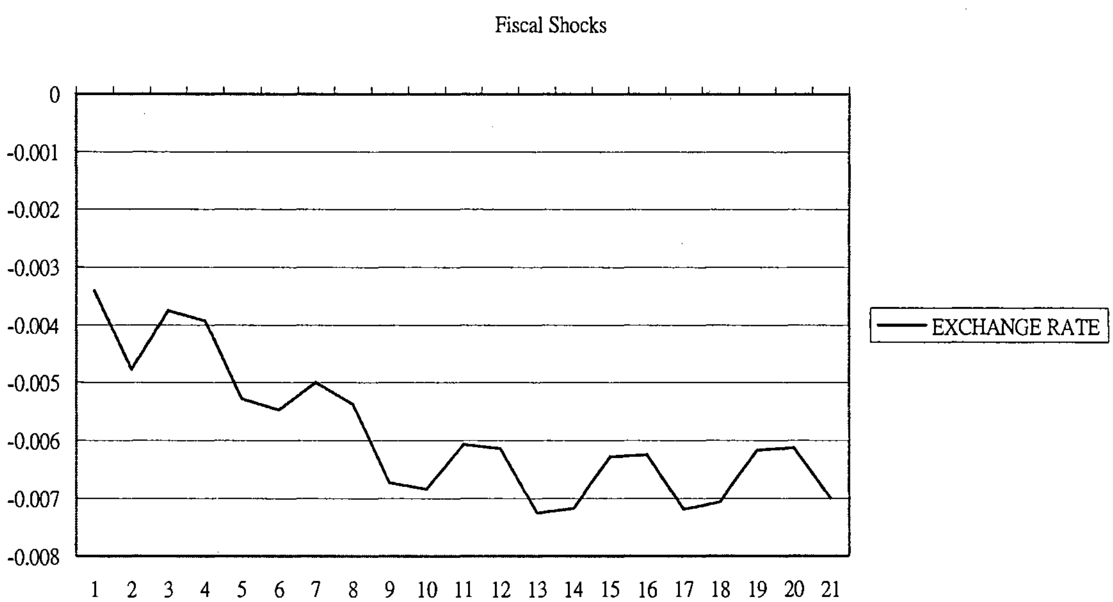


Figure 4-3 (c) Accumulated Response of Exchange Rate to

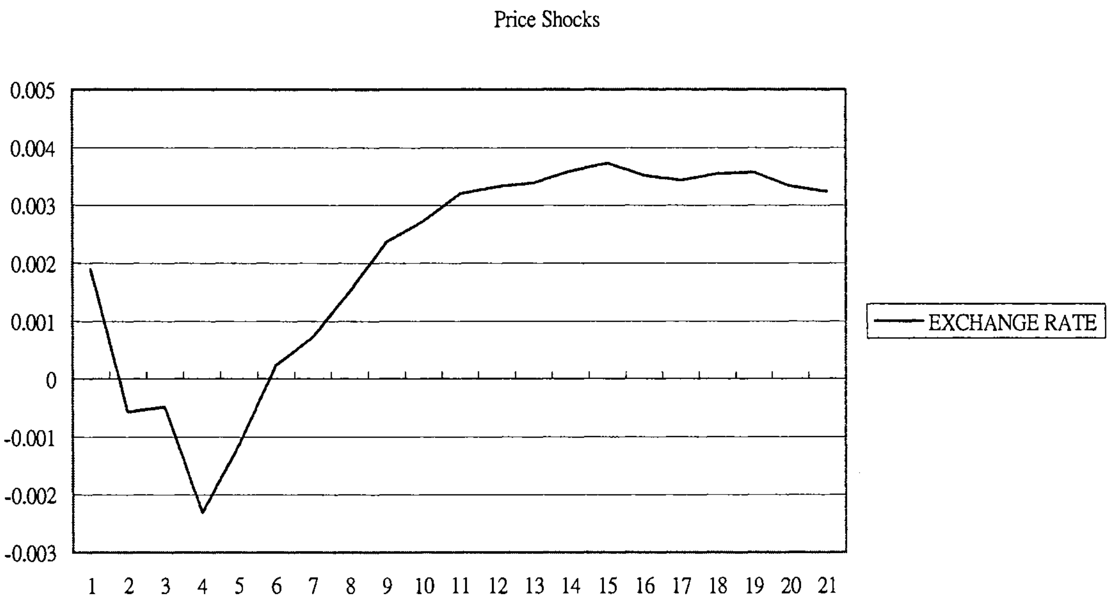


Figure 4-3 (d) Accumulated Response of Exchange Rate to

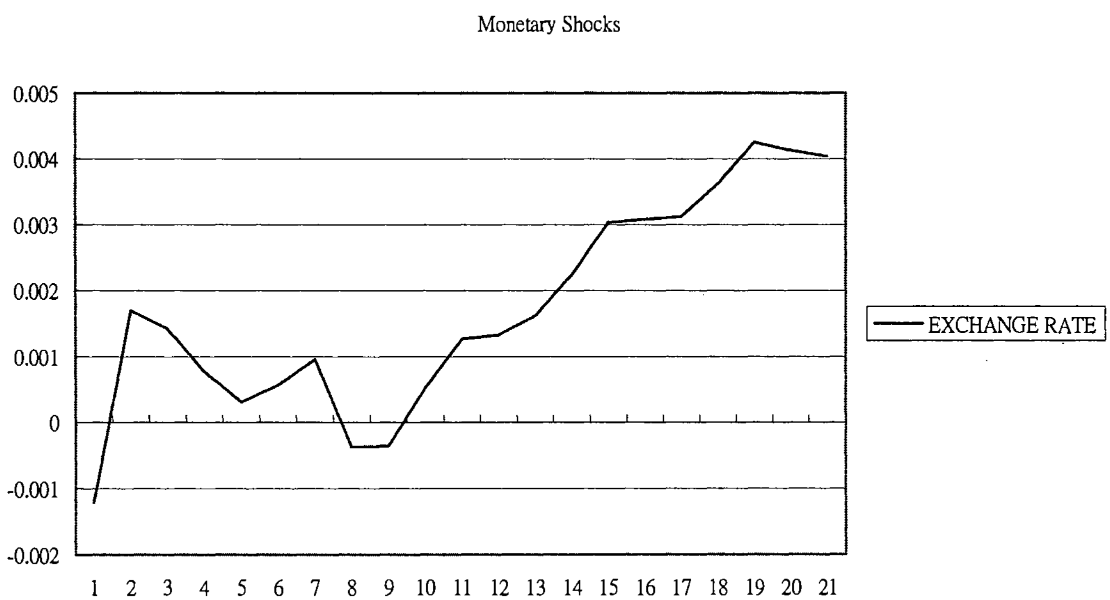


Figure 4-3 (e) Accumulated Response of Exchange Rate to

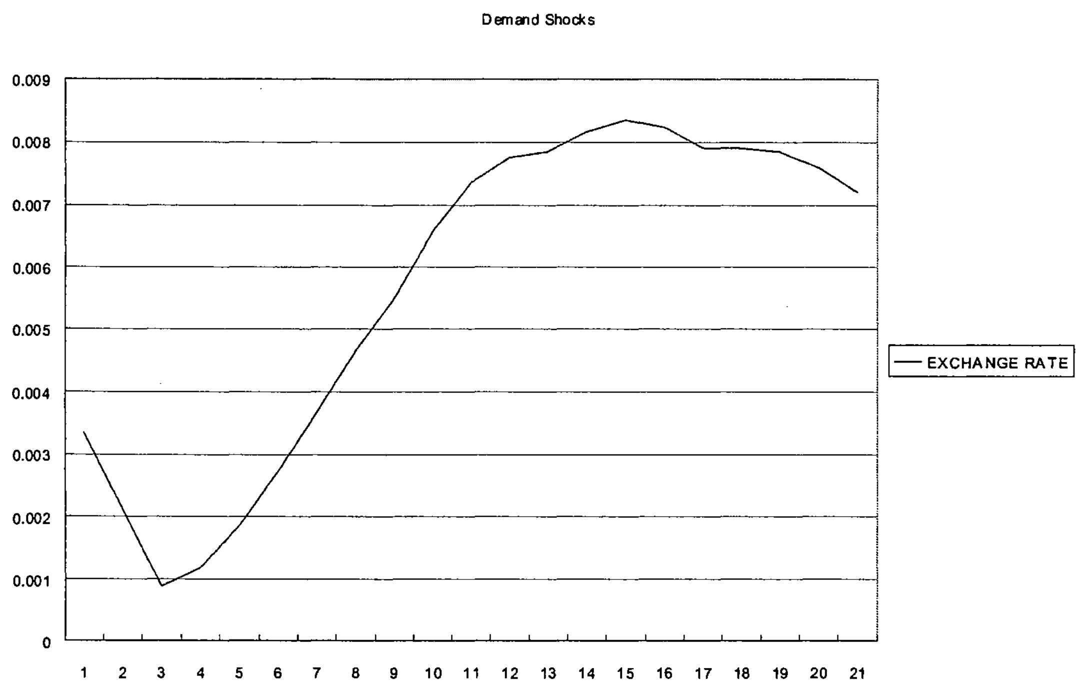


Figure 4-3 (f) Accumulated Response of Exchange Rate to

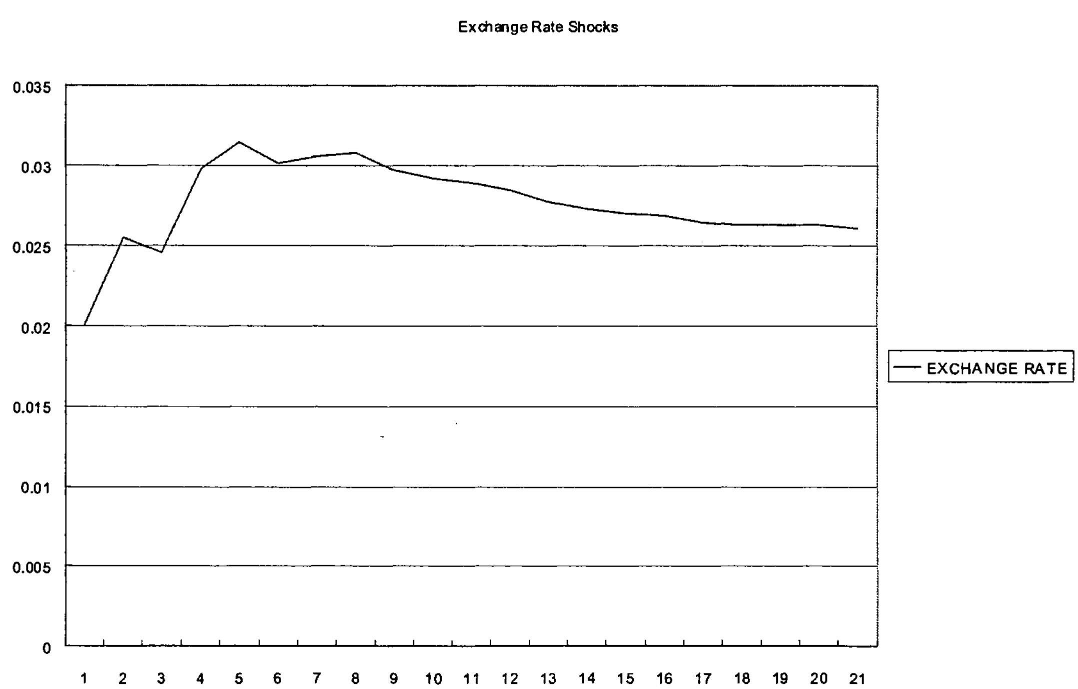


Figure 5-1 The Case of Taiwan (Restricted Karras Model)

Figure 5-1 (a) Accumulated Response of Output to

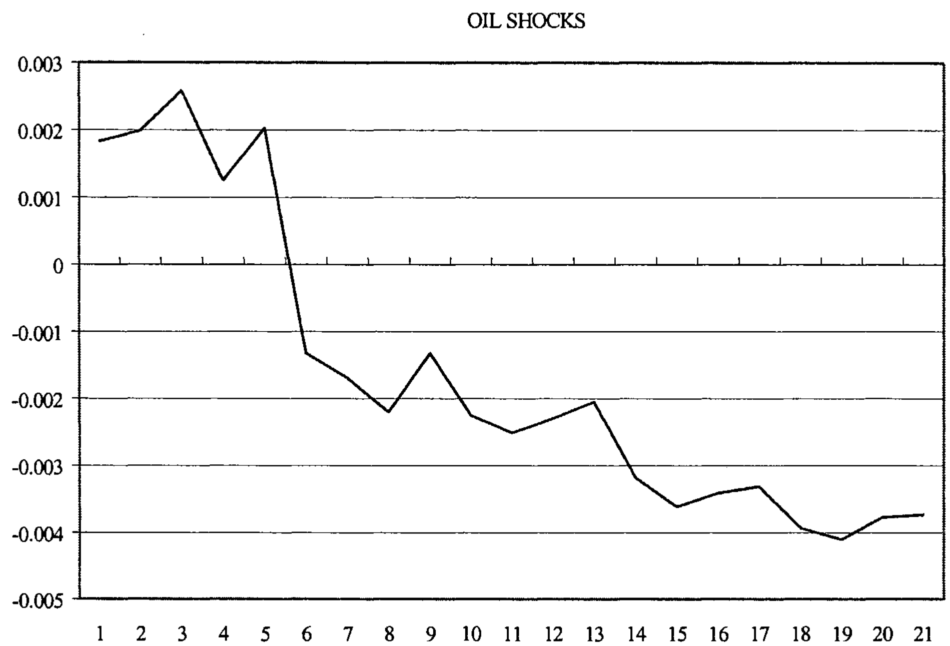


Figure 5-1 (b) Accumulated Response of Output to

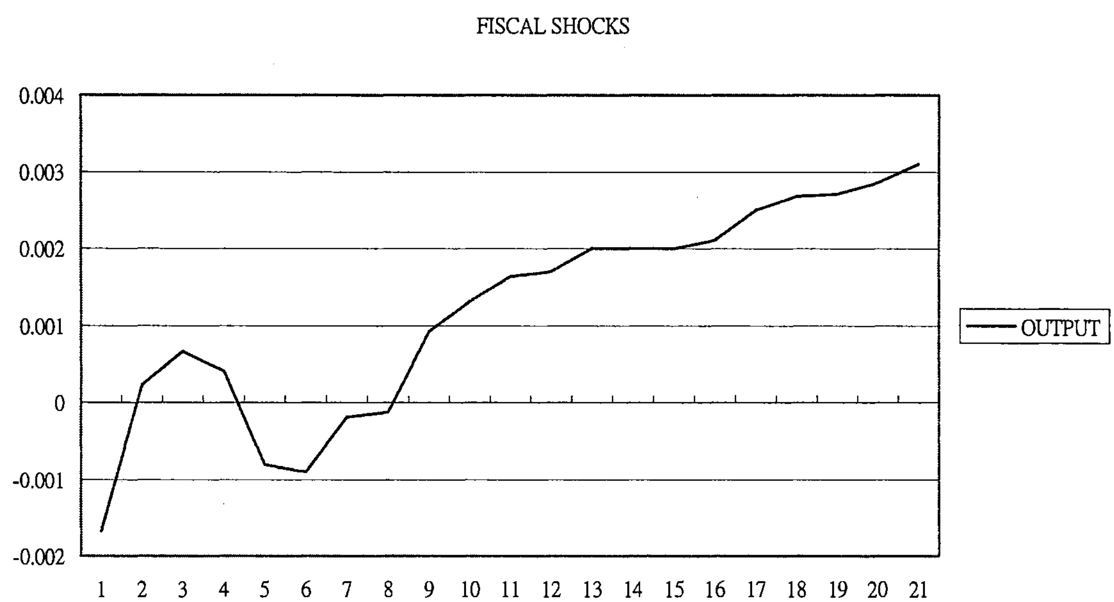


Figure 5-1 (c) Accumulated Response of Output to

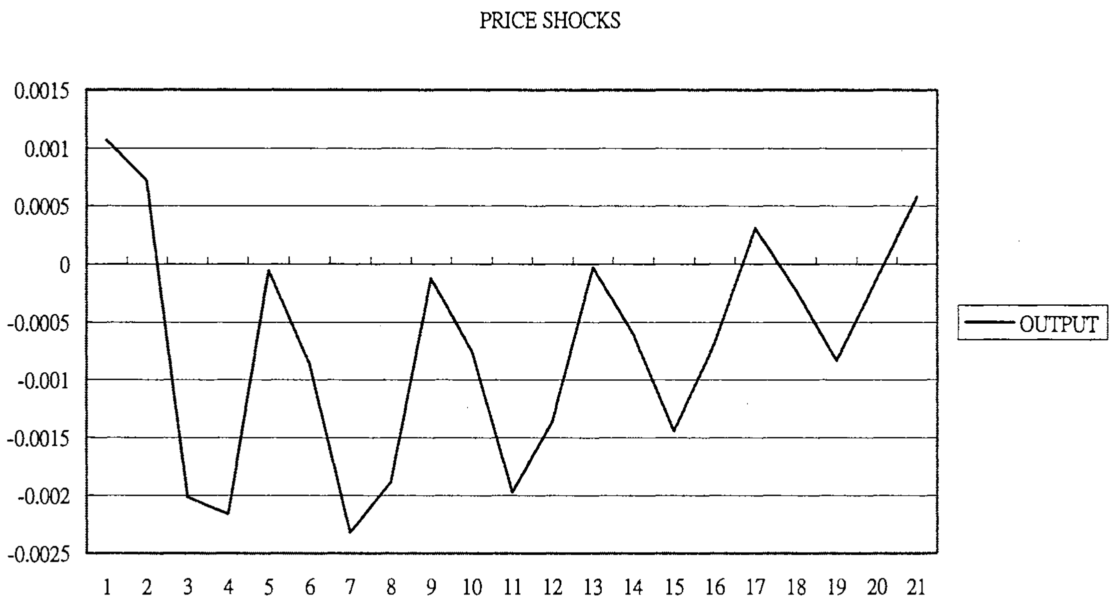


Figure 5-1 (d) Accumulated Response of Output to

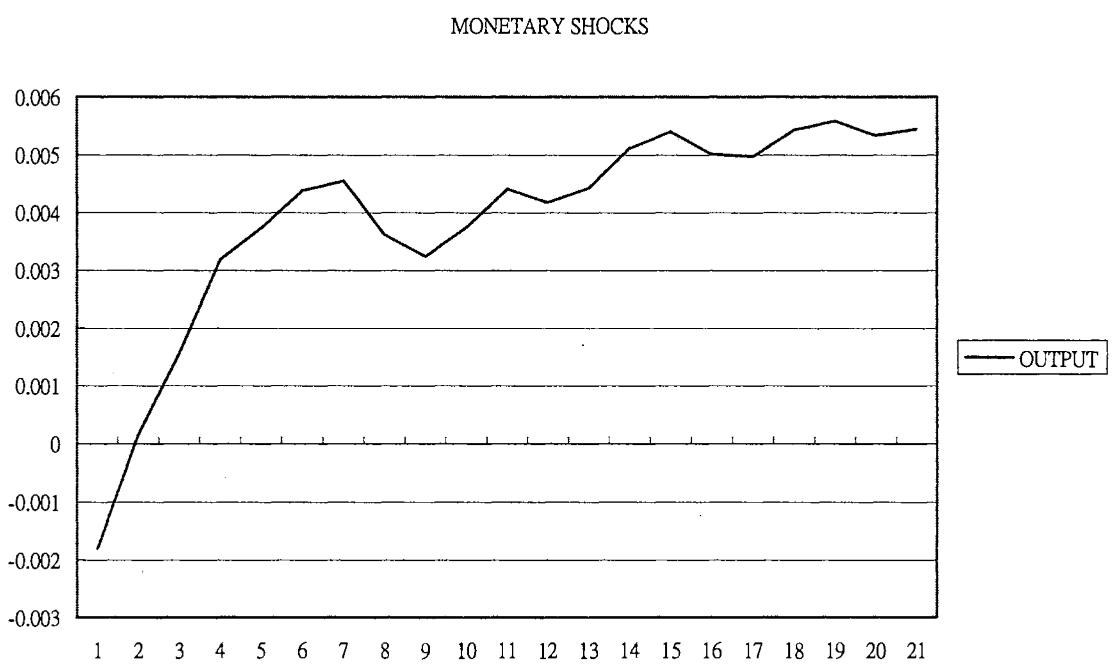


Figure 5-1 (e) Accumulated Response of Output to

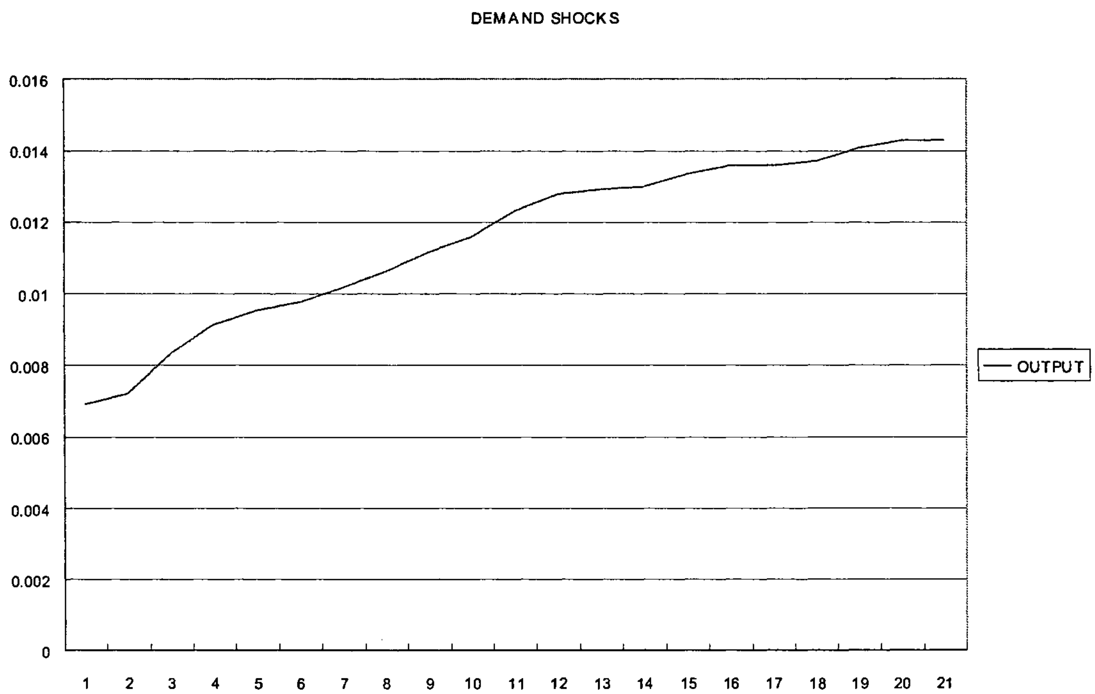


Figure 5-1 (f) Accumulated Response of Output to

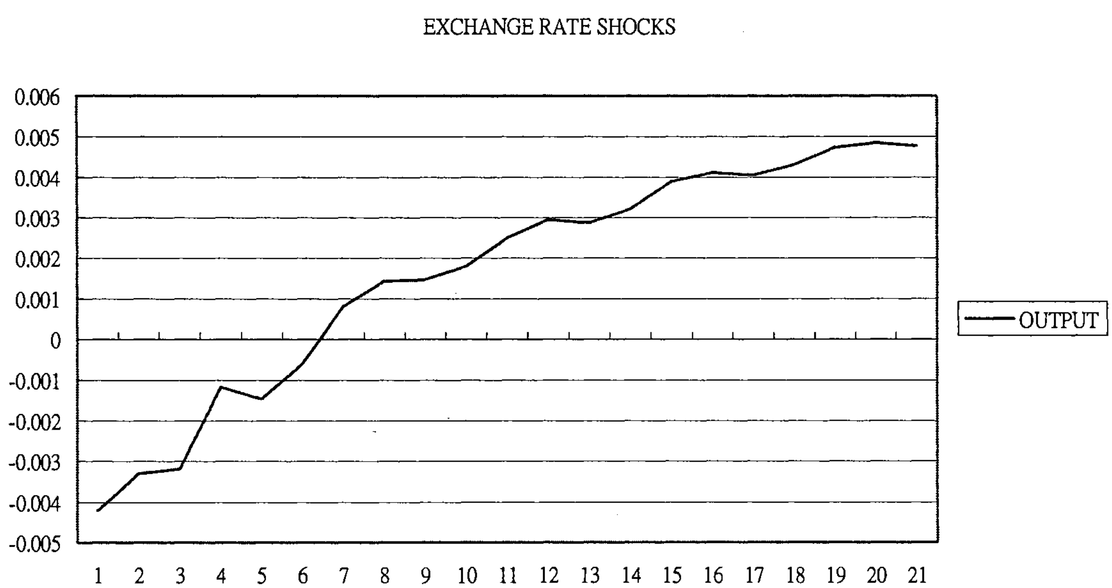


Figure 5-2 The Case of Taiwan (Restricted Karras Model)

Figure 5-2 (a) Accumulated Response of Price Level to

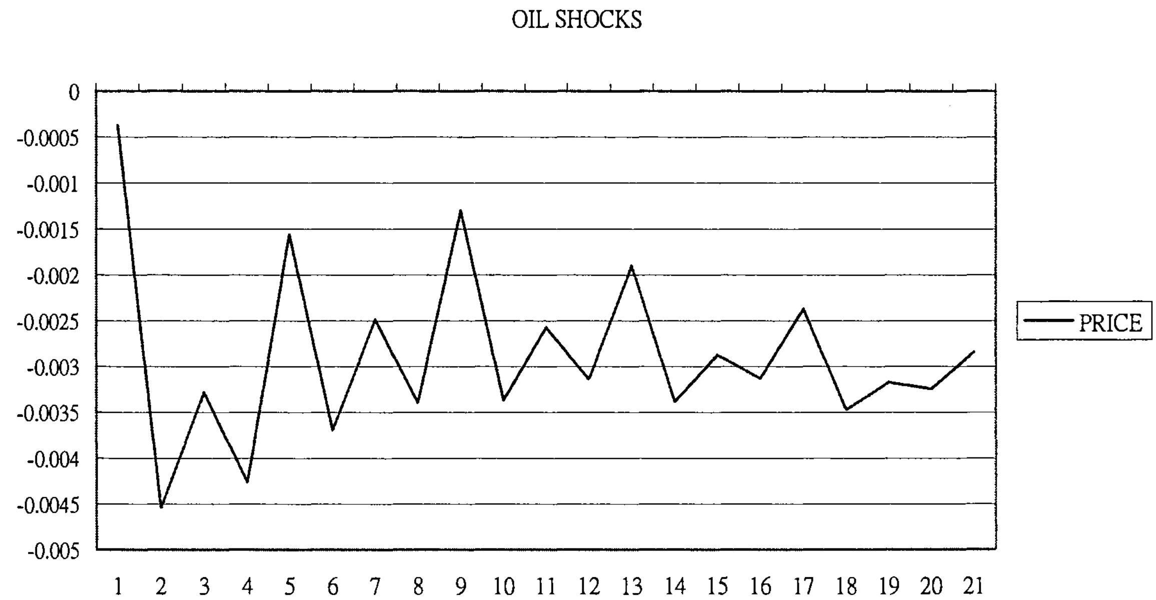


Figure 5-2 (b) Accumulated Response of Price Level to

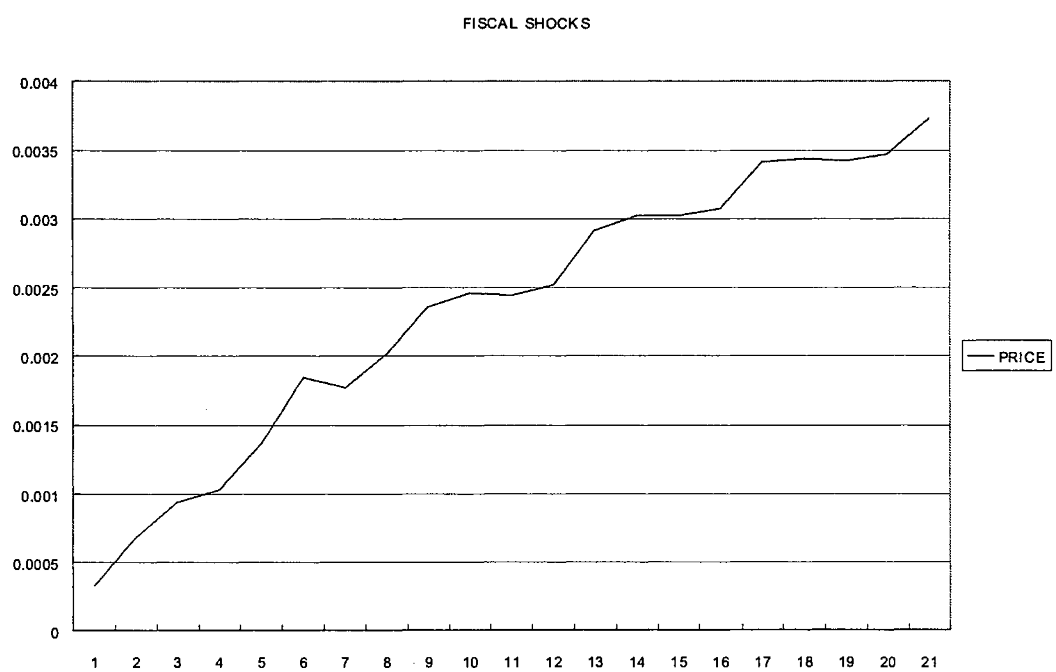


Figure 5-2 (c) Accumulated Response of Price Level to

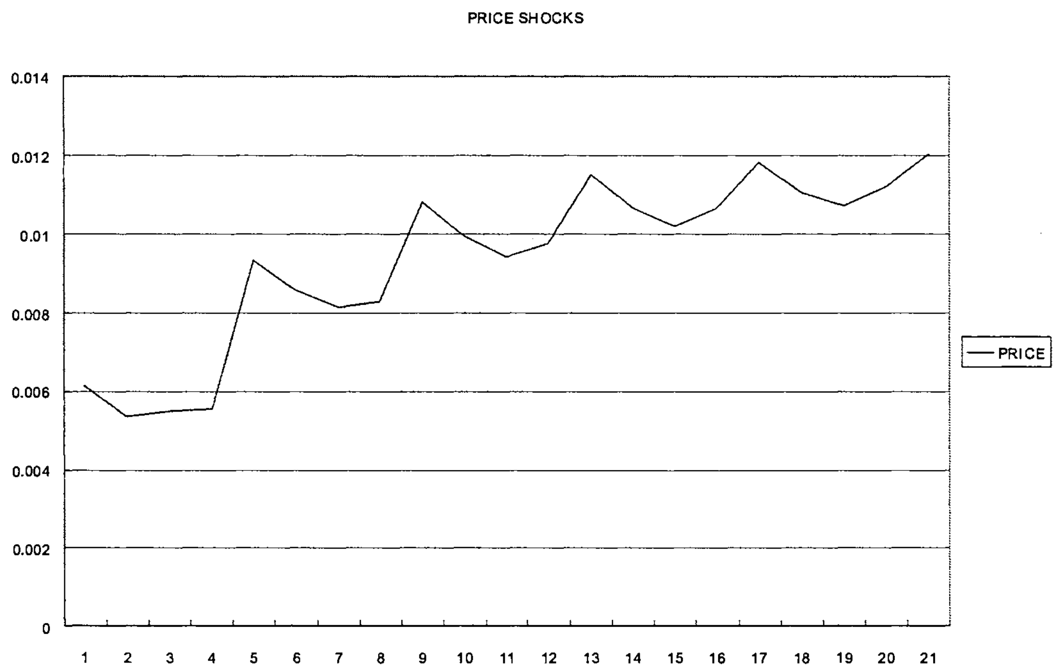


Figure 5-2 (d) Accumulated Response of Price Level to

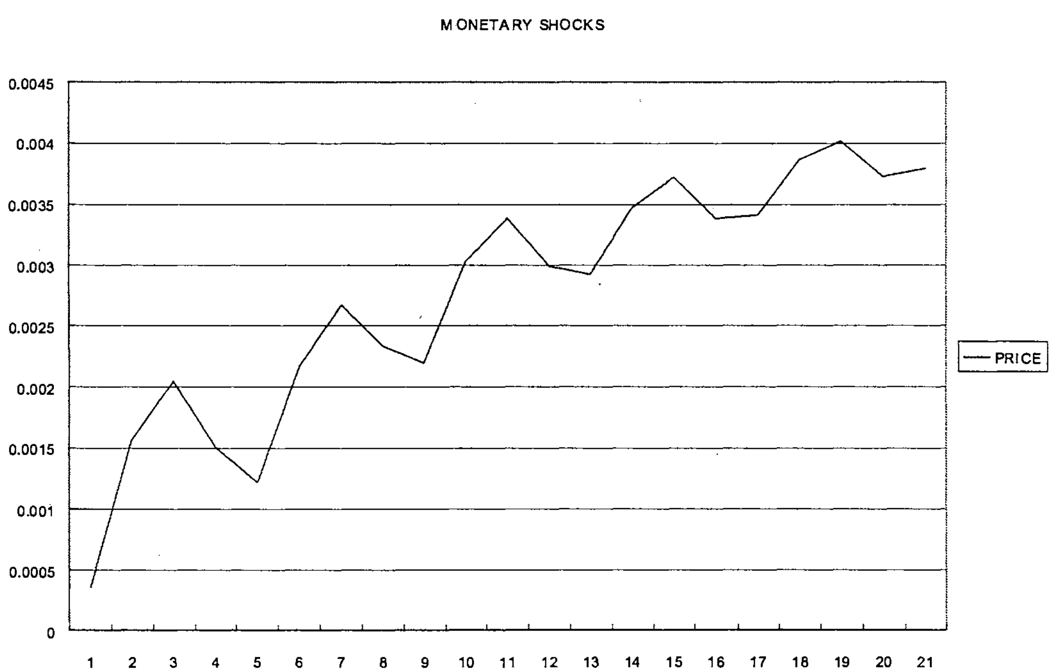


Figure 5-2 (e) Accumulated Response of Price Level to

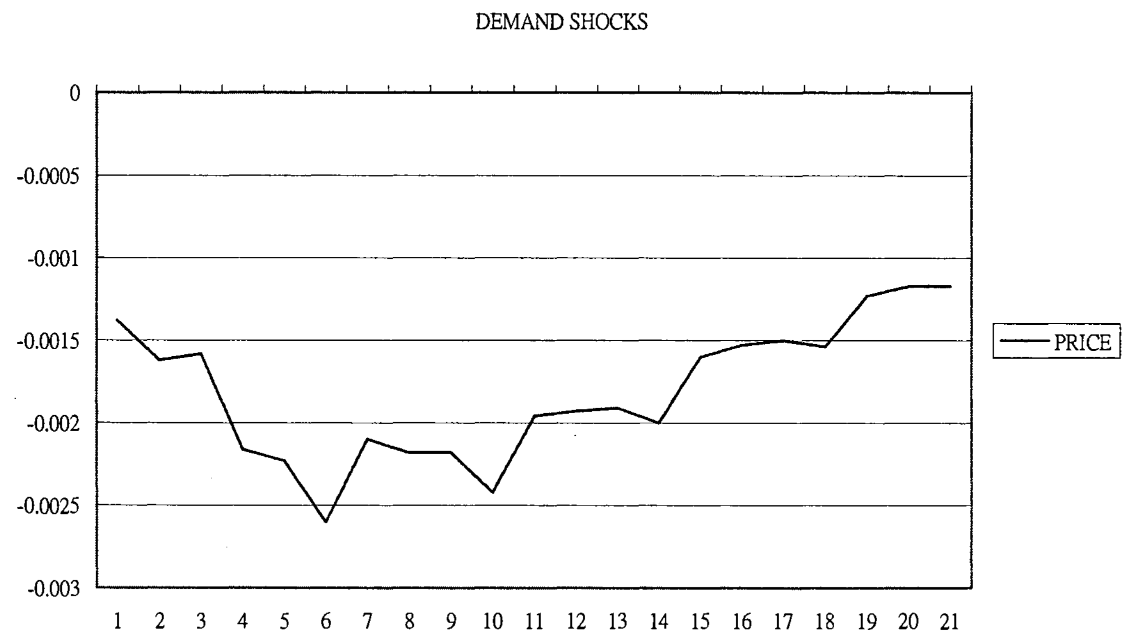


Figure 5-2 (f) Accumulated Response of Price Level to

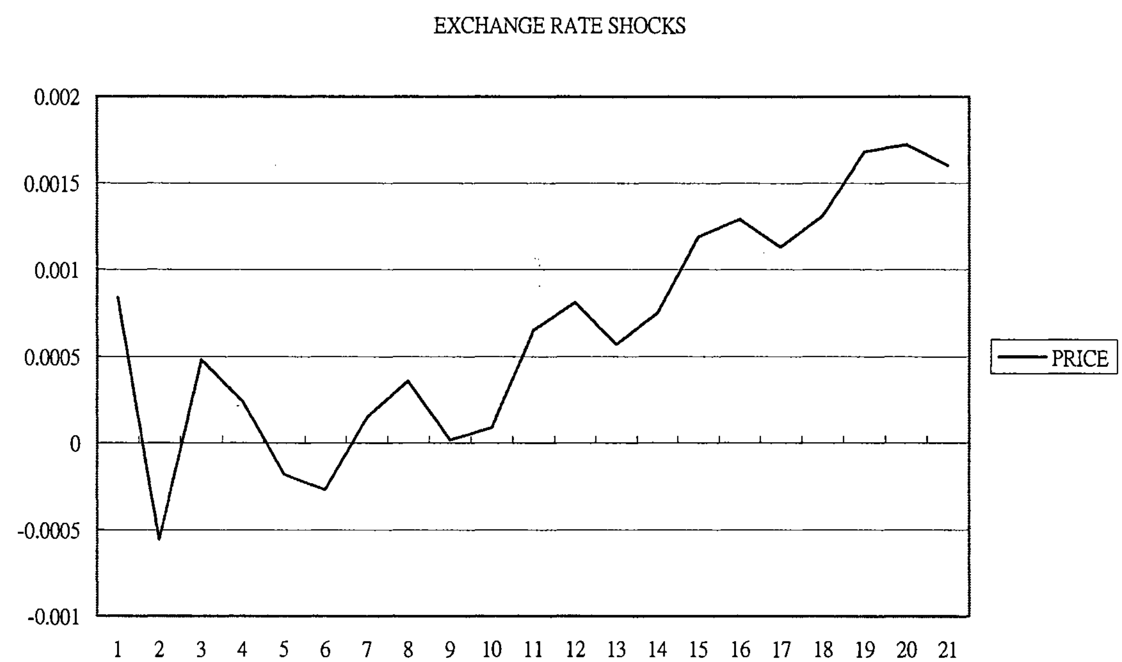


Figure 5-3 The Case of Taiwan (Restricted Karras Model)

Figure 5-3 (a) Accumulated Response of Exchange Rate to

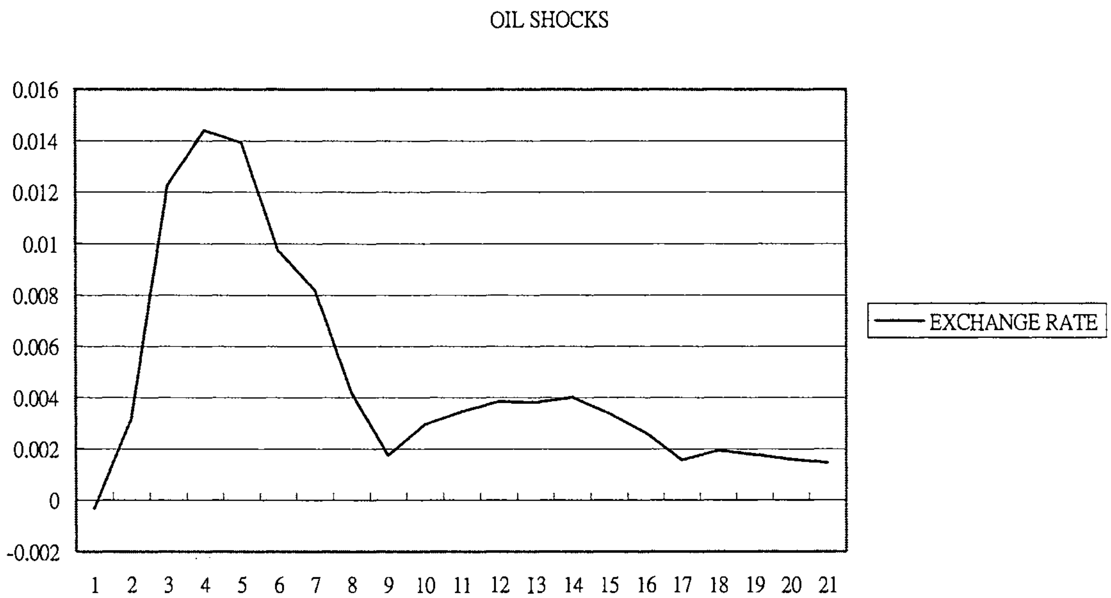


Figure 5-3 (b) Accumulated Response of Exchange Rate to

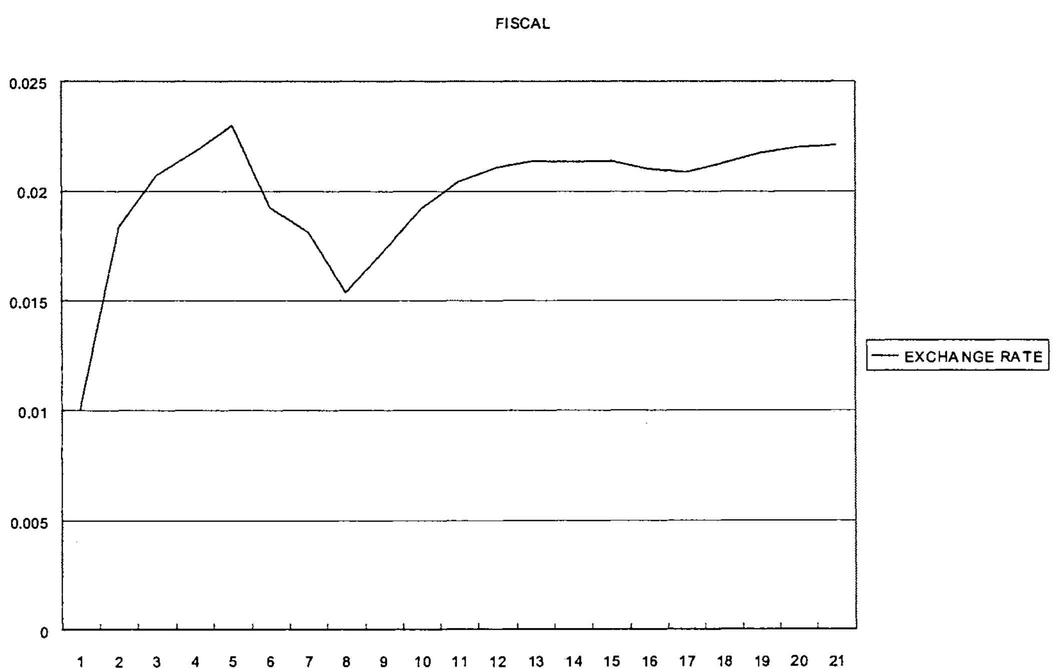


Figure 5-3 (c) Accumulated Response of Exchange Rate to

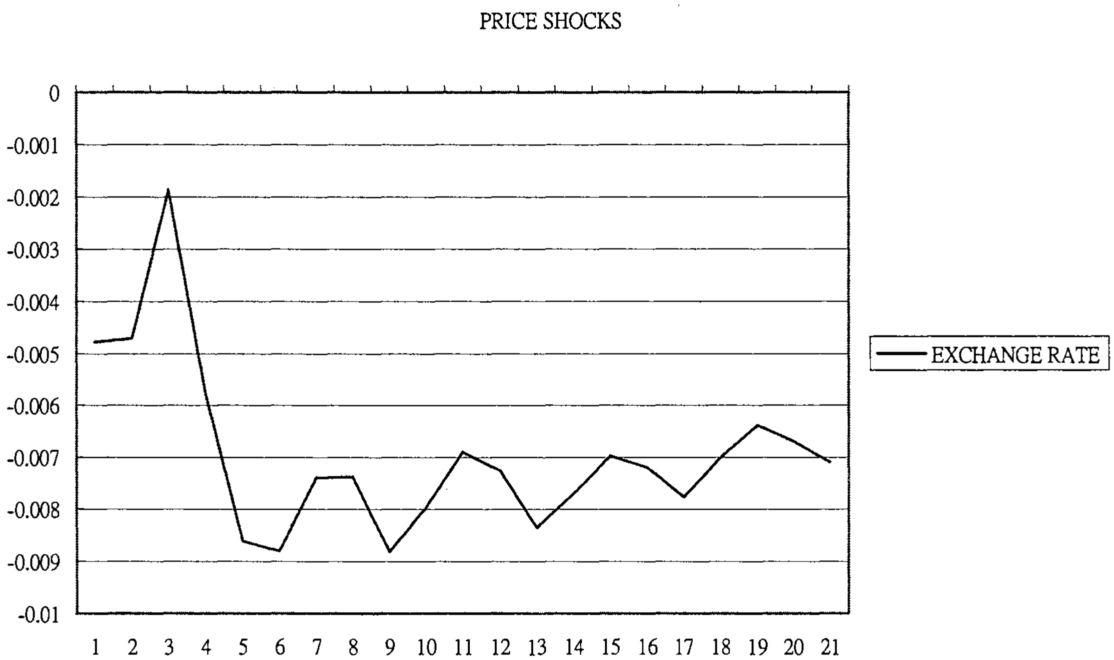


Figure 5-3 (d) Accumulated Response of Exchange Rate to

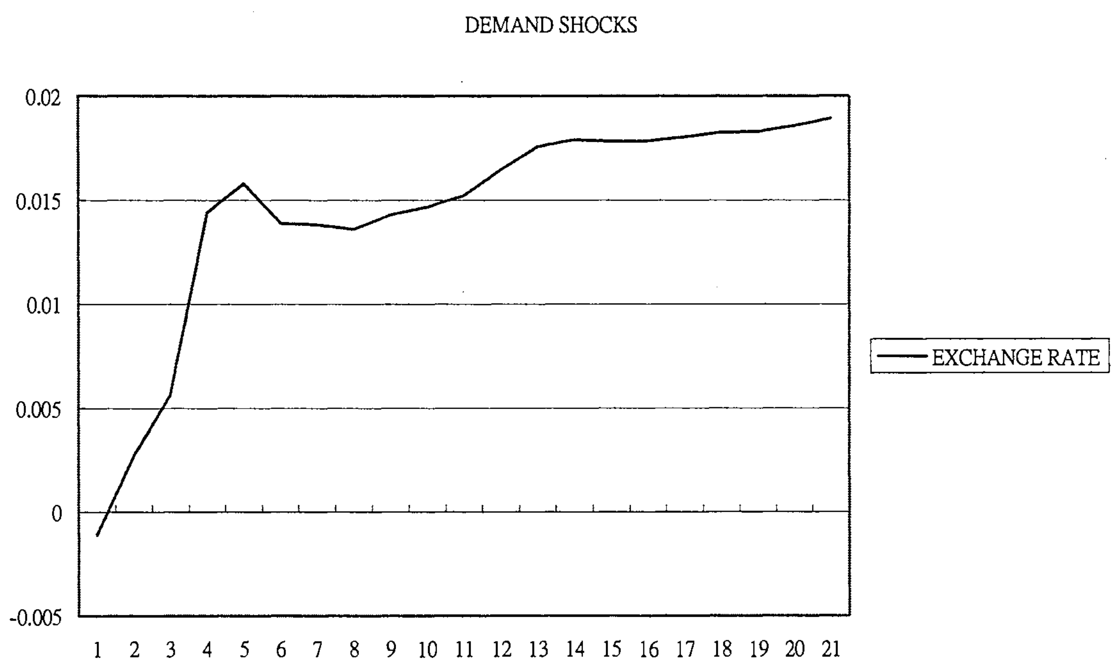


Figure 5-3 (e) Accumulated Response of Exchange Rate to

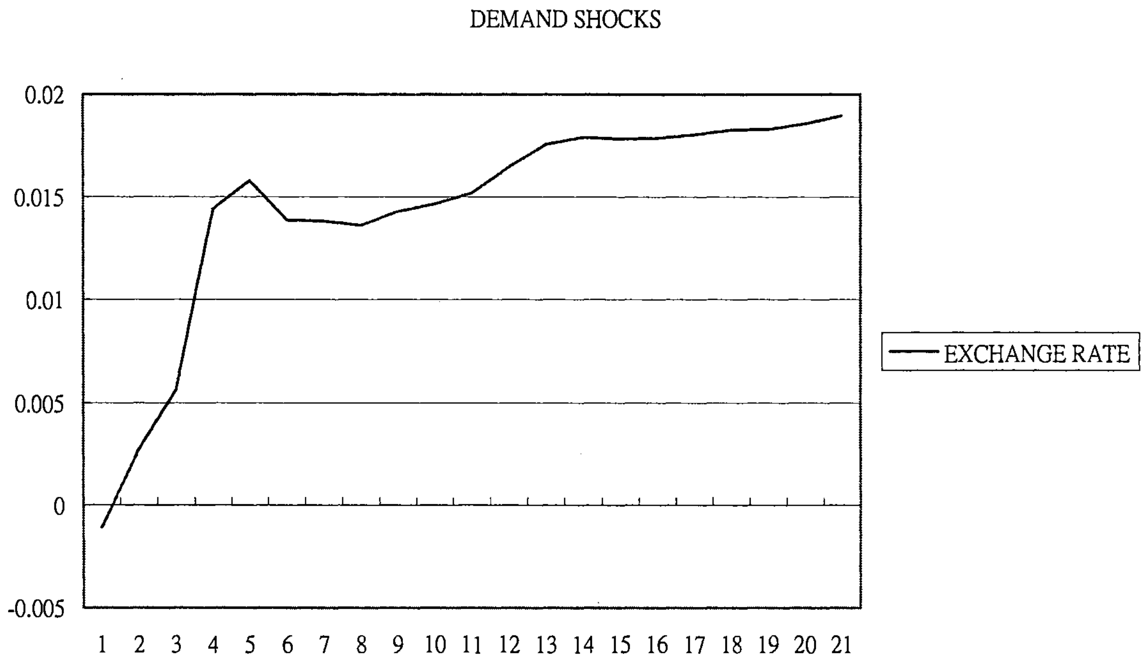


Figure 5-3 (f) Accumulated Response of Exchange Rate to

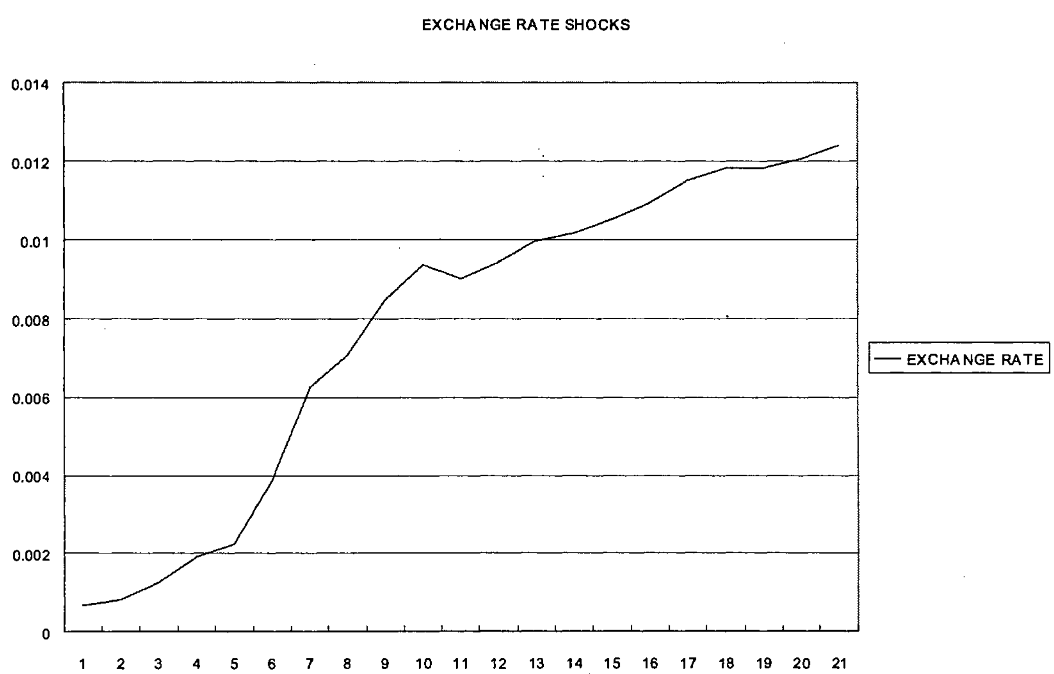


Figure 5-4 The Case of Taiwan (Unrestricted Karras Model)

Figure 5-4 (a) Accumulated Response of Output to

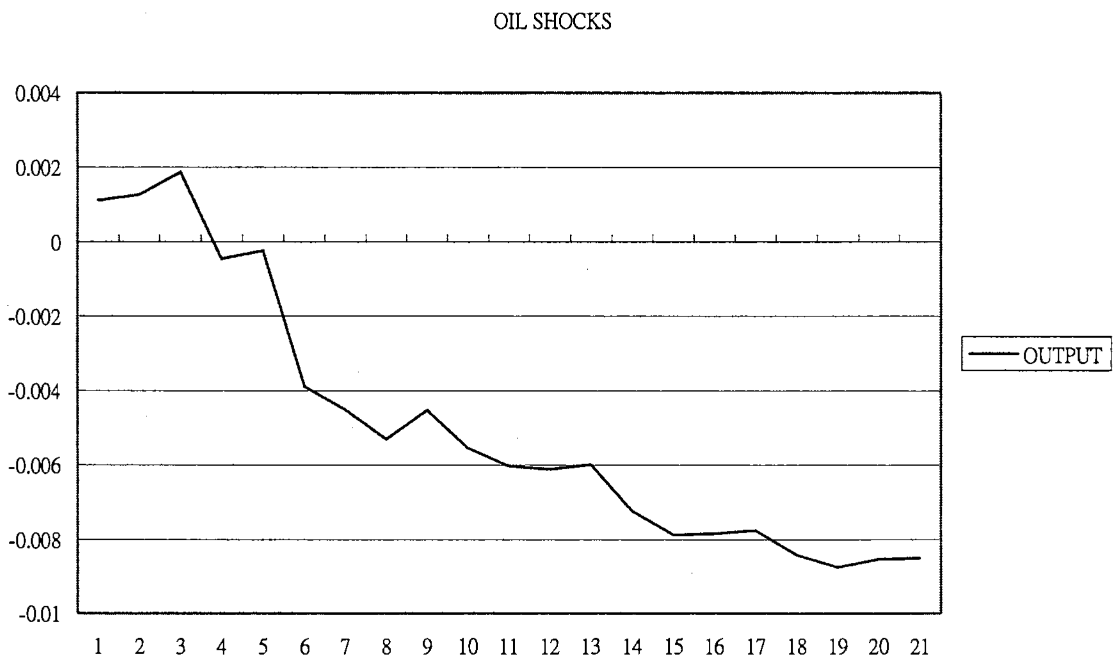


Figure 5-4 (b) Accumulated Response of Output to

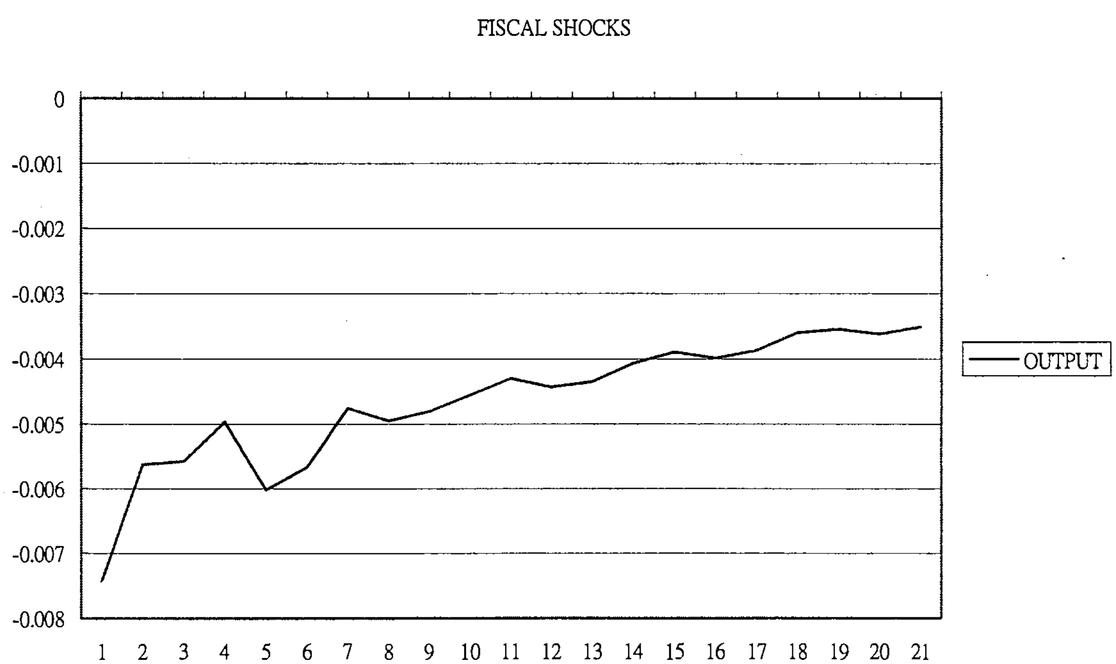


Figure 5-4 (c) Accumulated Response of Output to

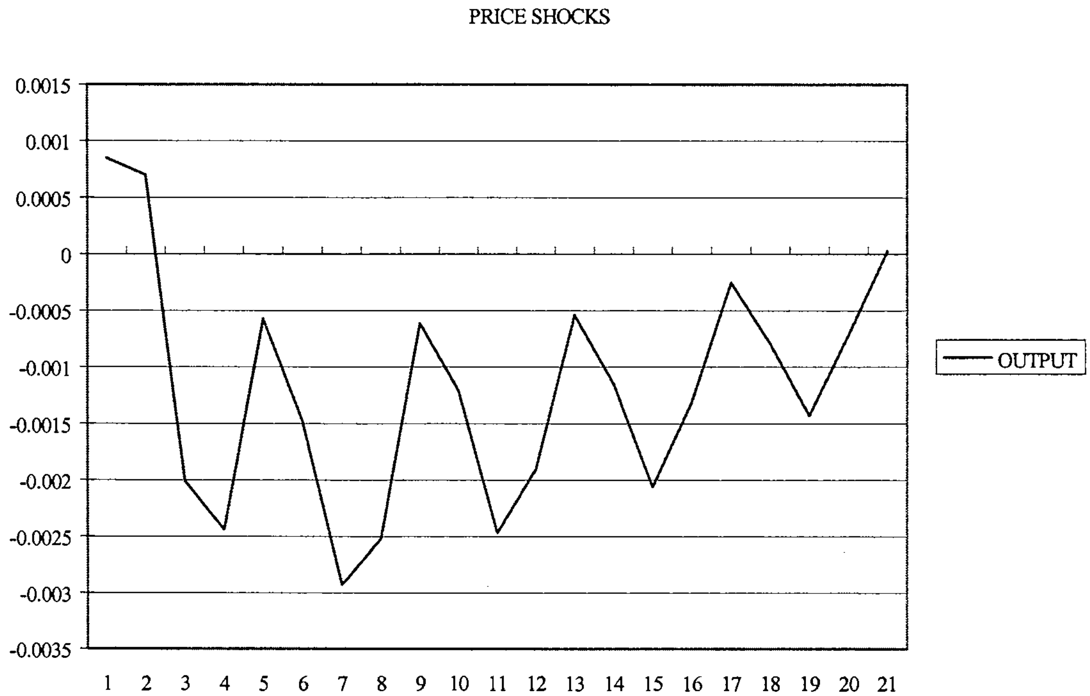


Figure 5-4 (d) Accumulated Response of Output to

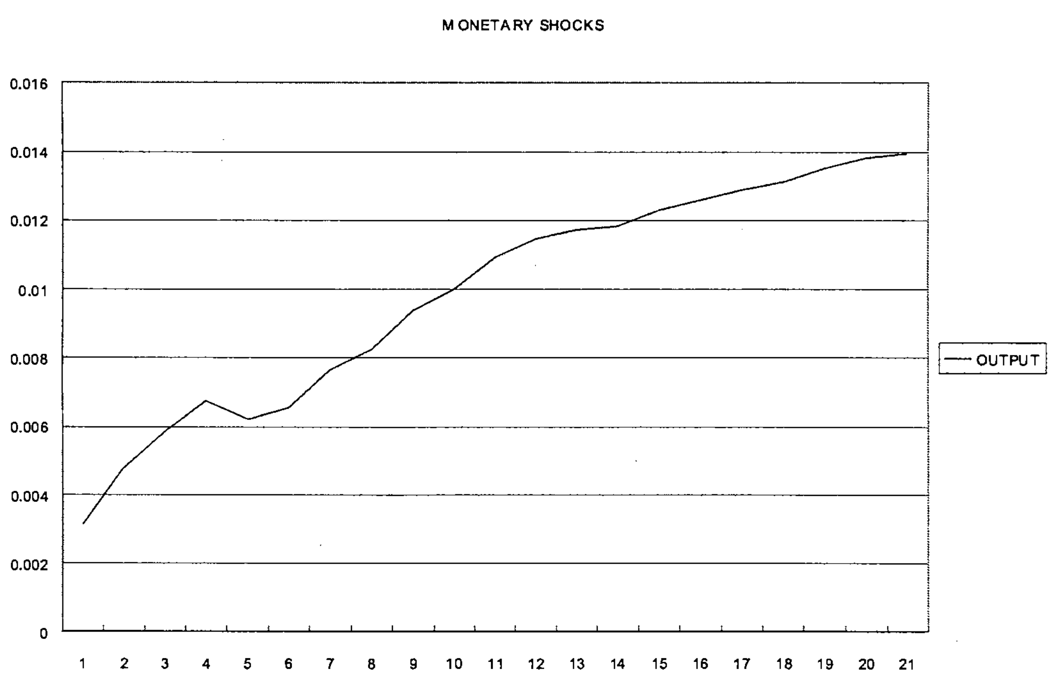


Figure 5-4 (e) Accumulated Response of Output to

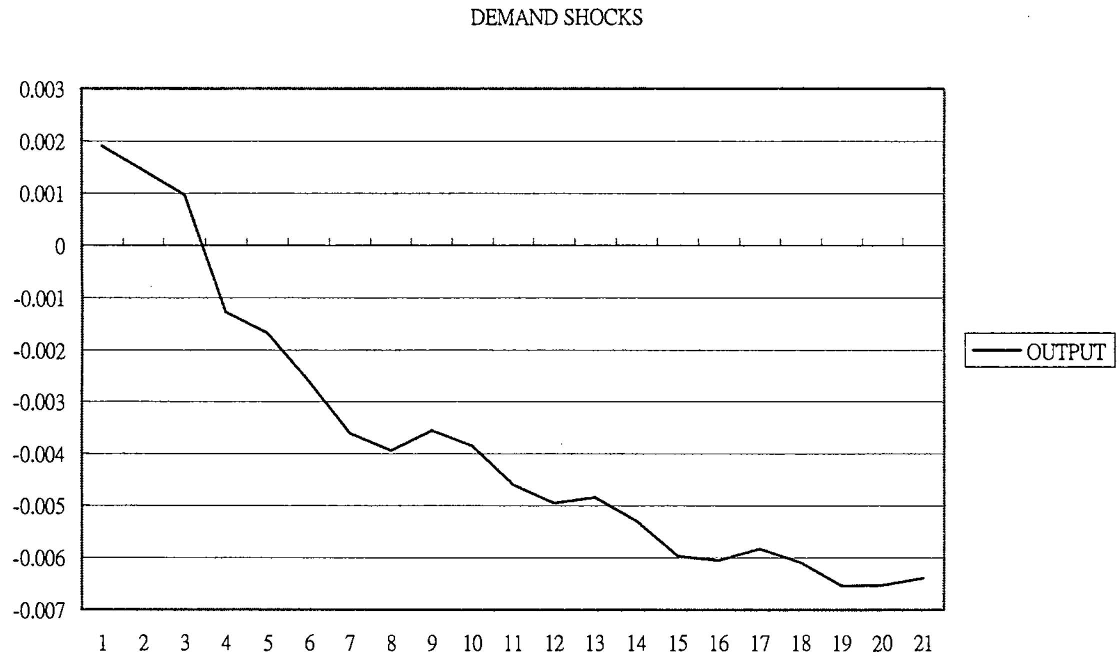


Figure 5-4 (f) Accumulated Response of Output to

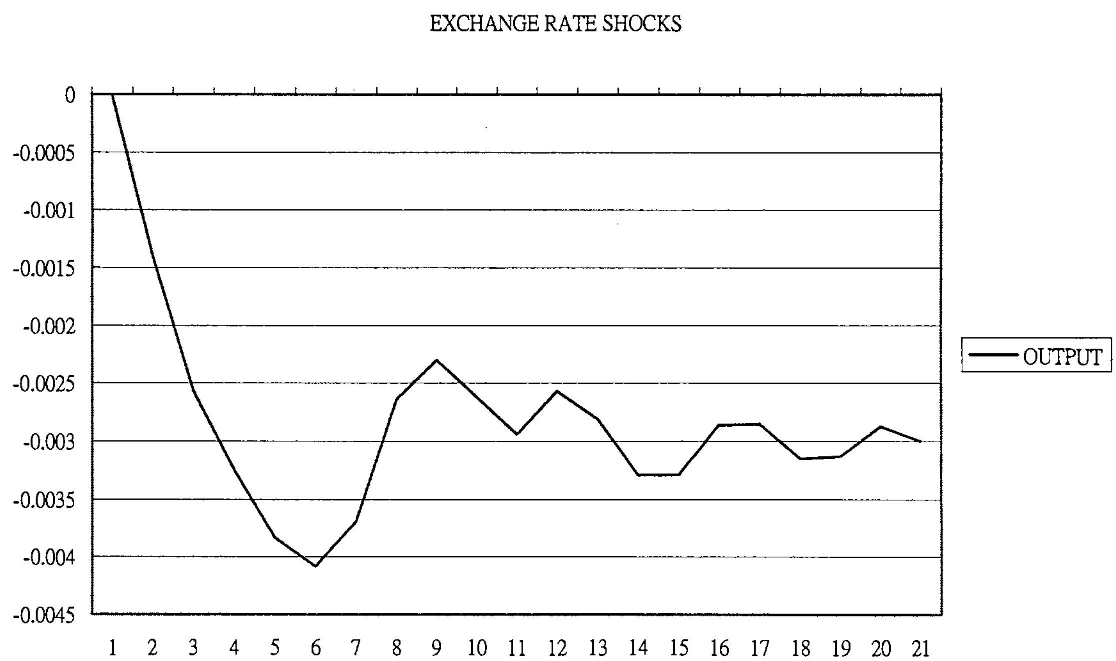


Figure 5-5 The Case of Taiwan (unrestricted Karras Model)

Figure 5-5 (a) Accumulated Response of Price Level to

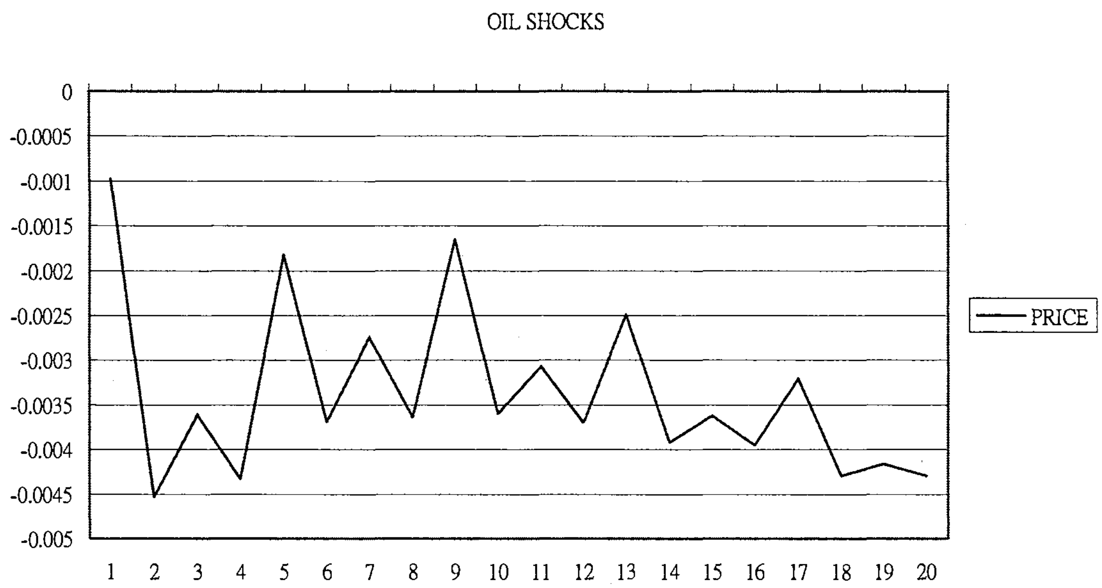


Figure 5-5 (b) Accumulated Response of price Level to

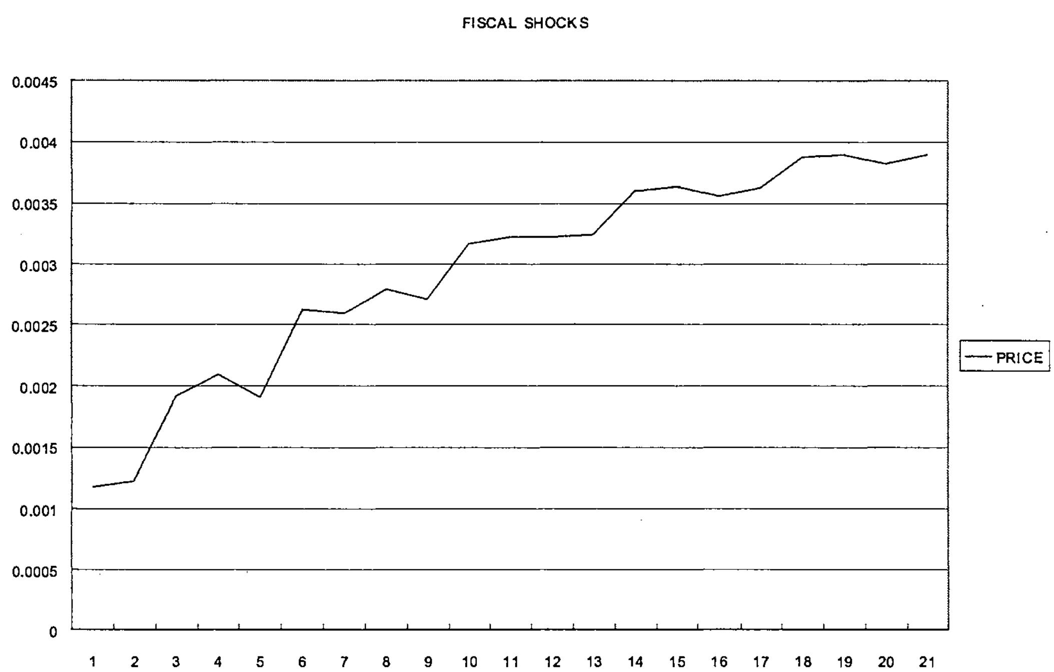


Figure 5-5 (c) Accumulated Response of Price Level to

PRICE SHOCKS

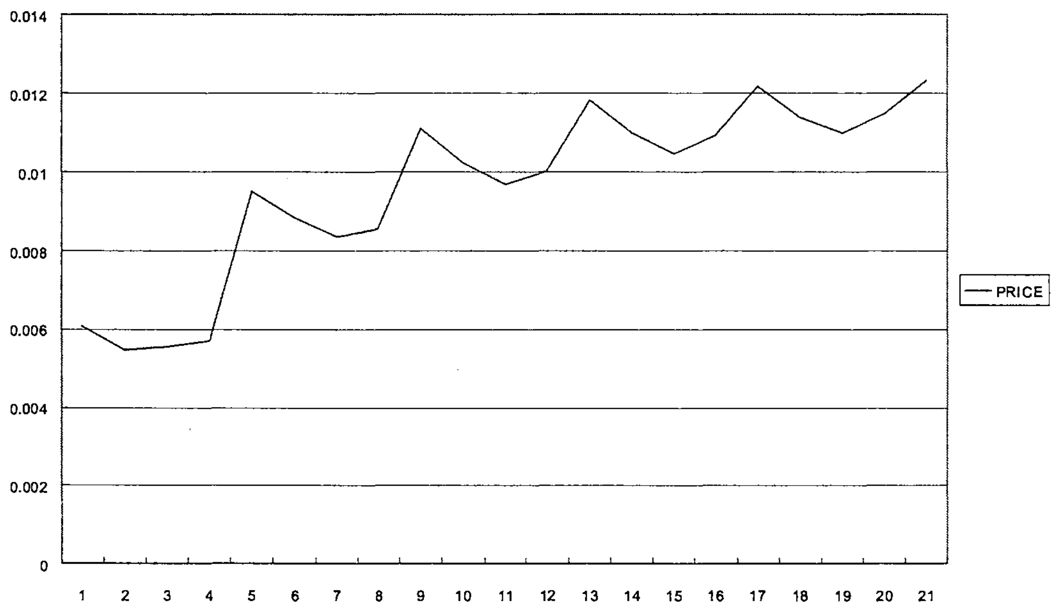


Figure 5-5 (d) Accumulated Response of Price Level to

MONETARY SHOCKS

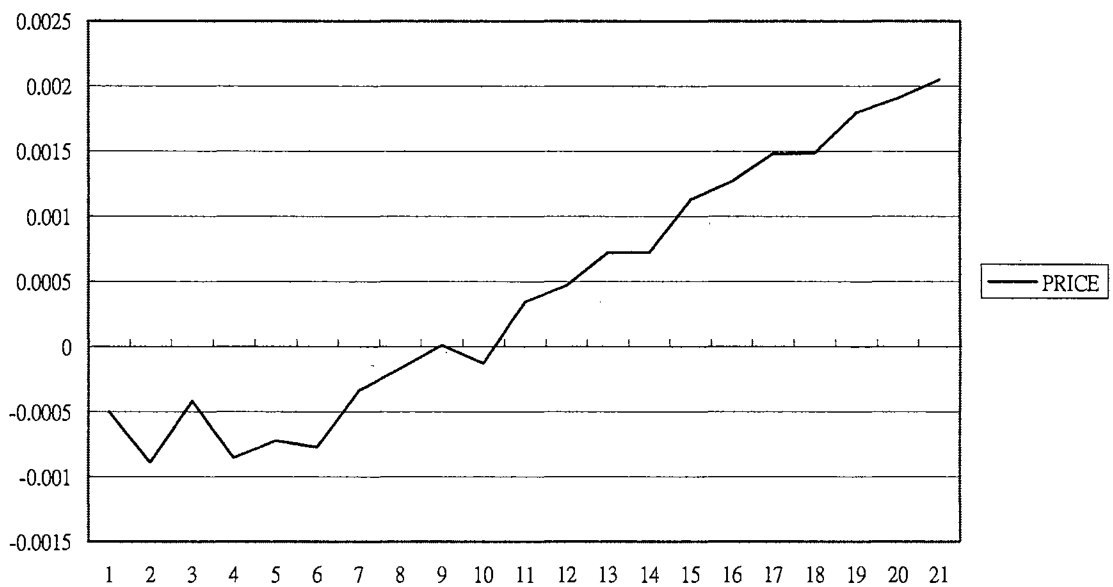


Figure 5-5 (e) Accumulated Response of Price Level to

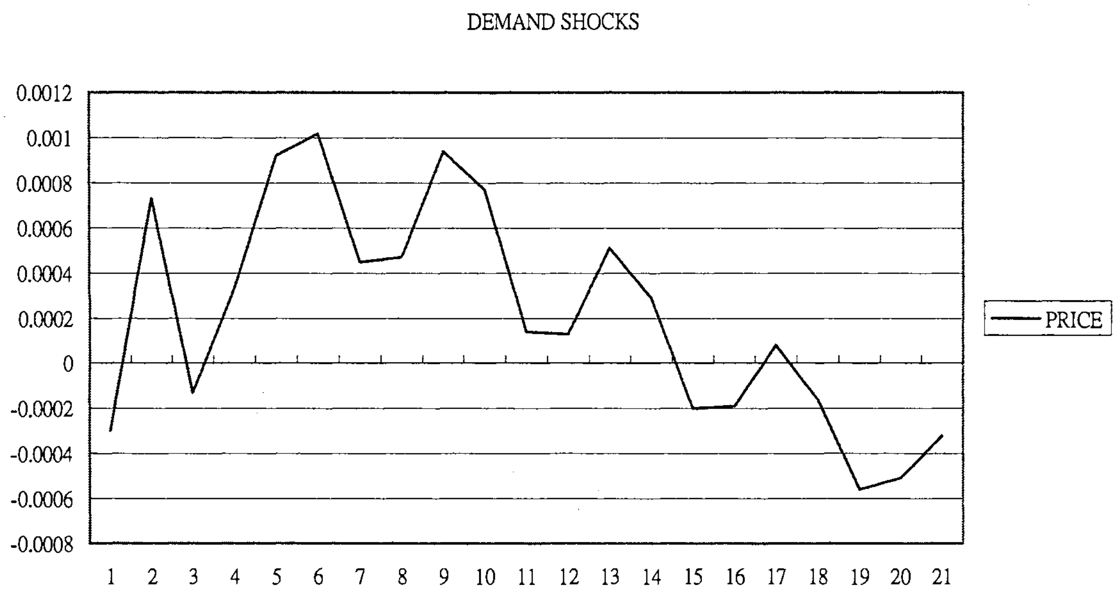


Figure 5-5 (f) Accumulated Response of Price Level to

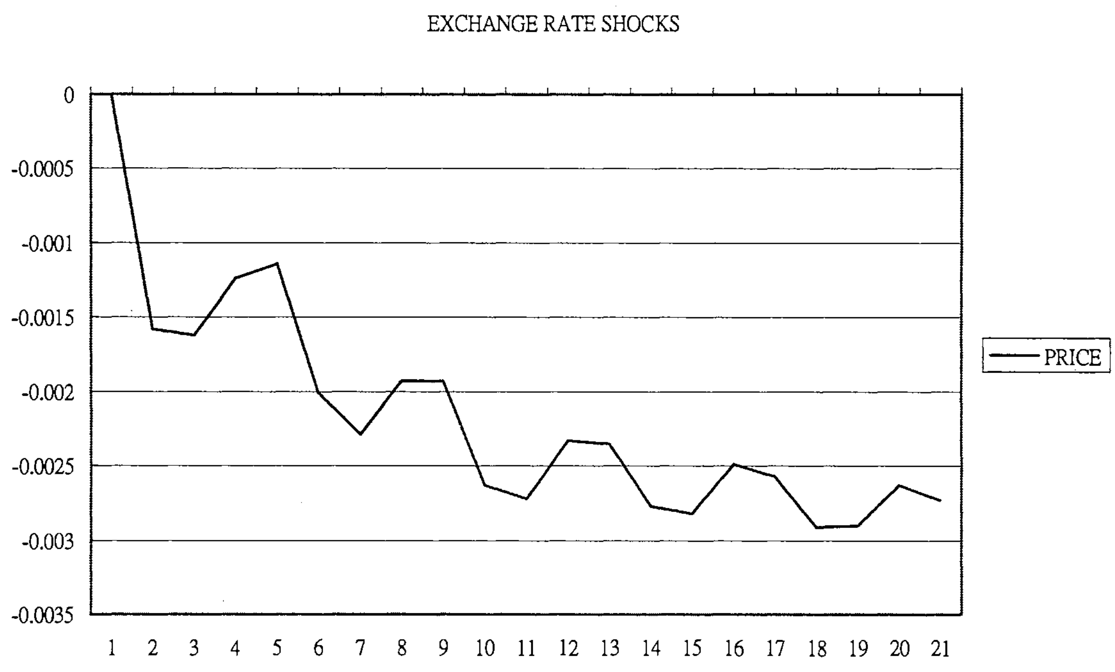


Figure 5-6 The Case of Taiwan (Unrestricted Karras Model)

Figure 5-6 (a) Accumulated Response of Exchange Rate to

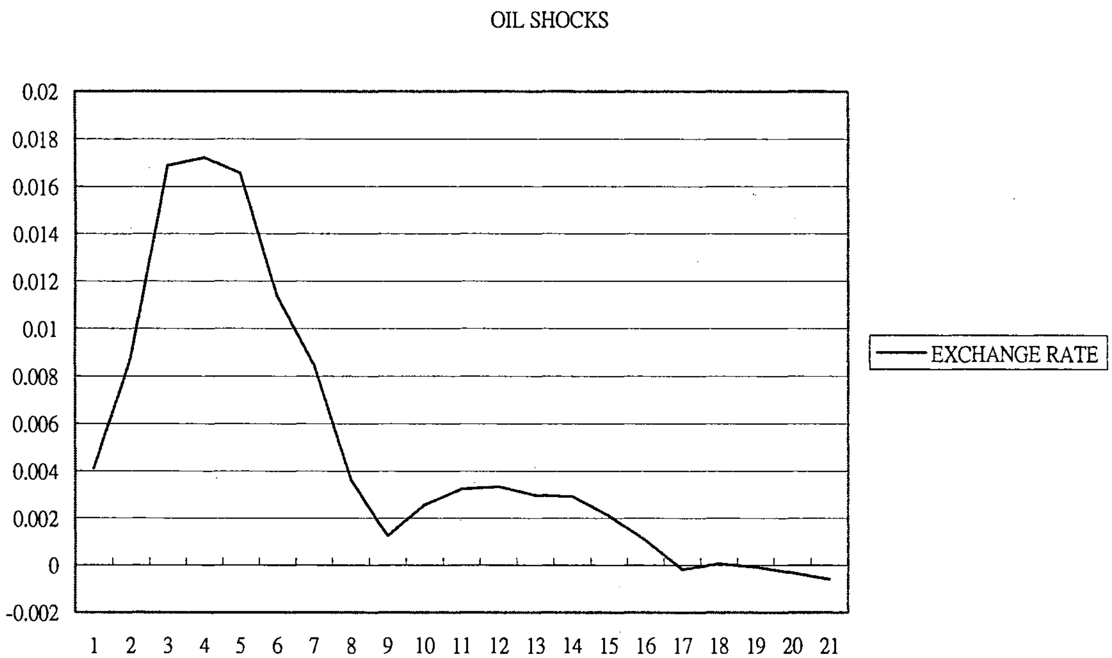


Figure 5-6 (b) Accumulated Response of Exchange Rate to

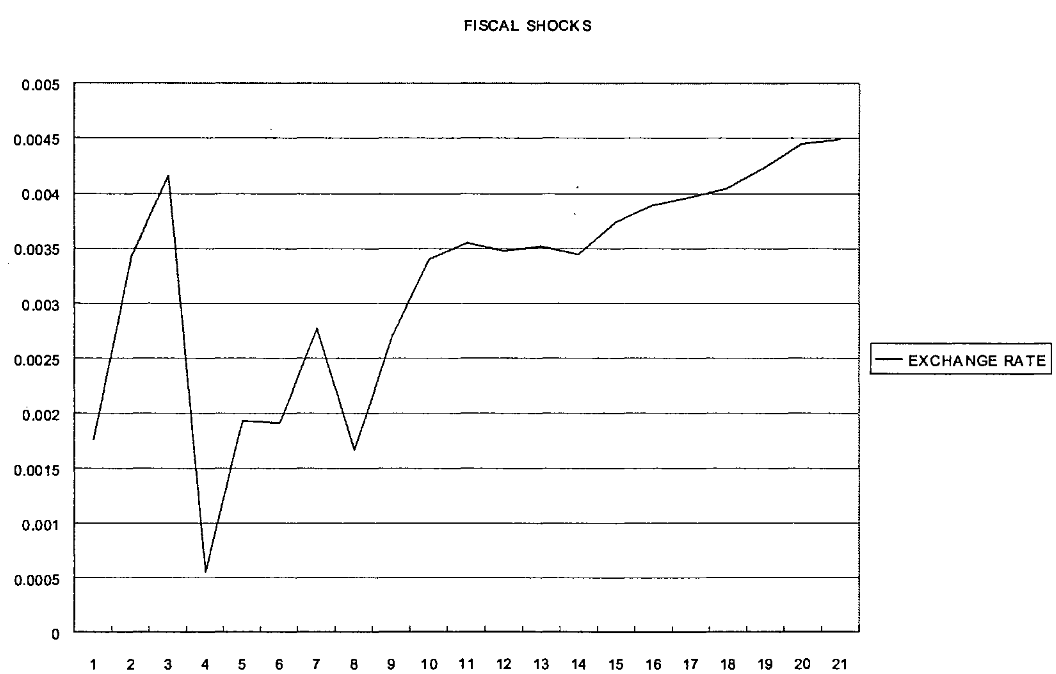


Figure 5-6 (c) Accumulated Response of Exchange Rate to

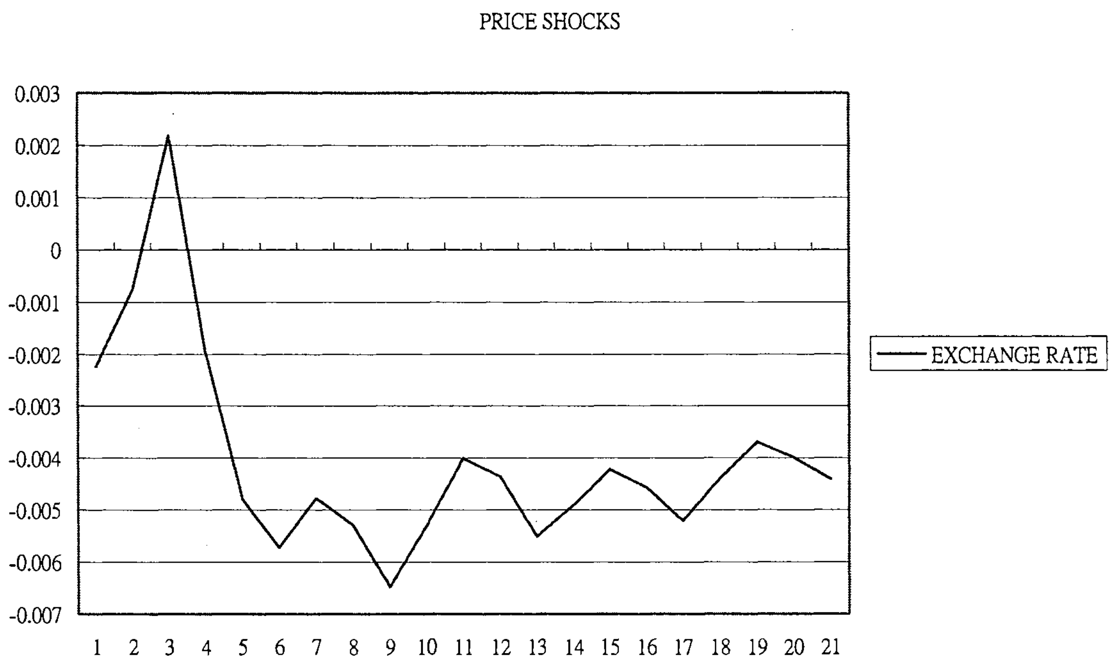


Figure 5-6 (d) Accumulated Response of Exchange Rate to

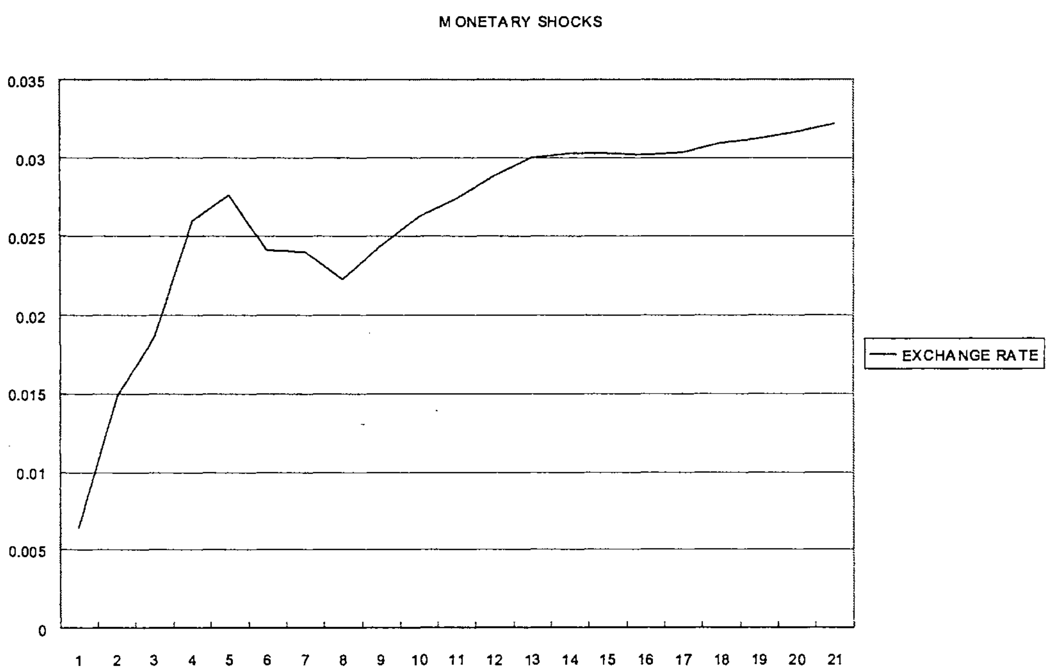


Figure 5-6 (e) Accumulated Response of Exchange Rate to

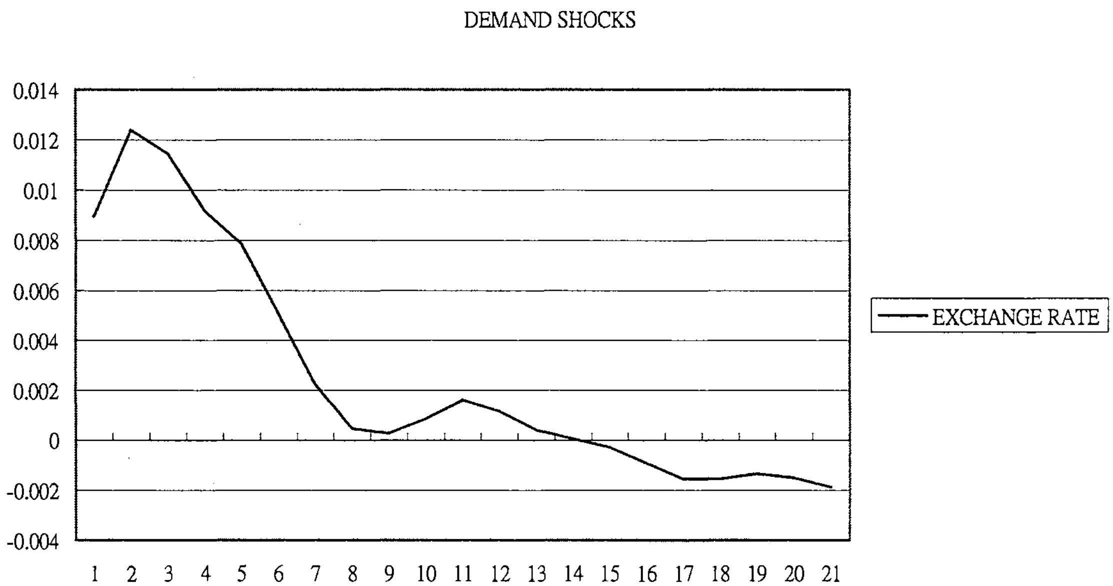


Figure 5-6 (f) Accumulated Response of Exchange Rate to

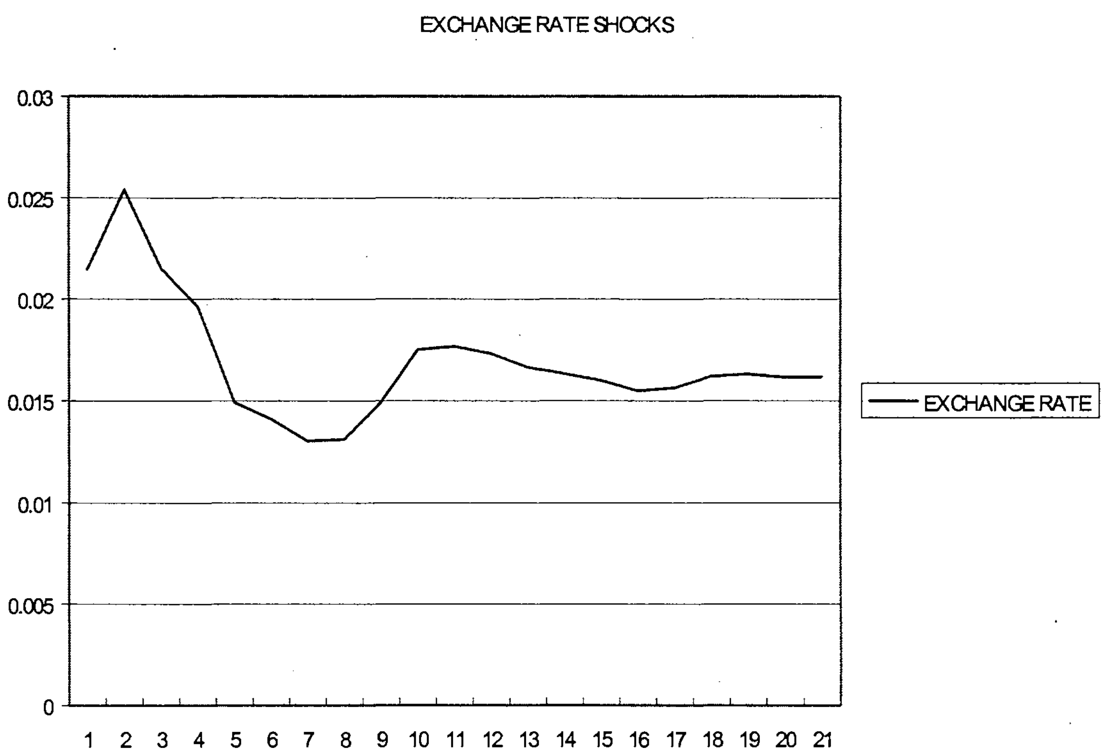


Figure 5-7 The Case of Taiwan (Choleski Decomposition)

Figure 5-7 (a) Accumulated Response of Output to

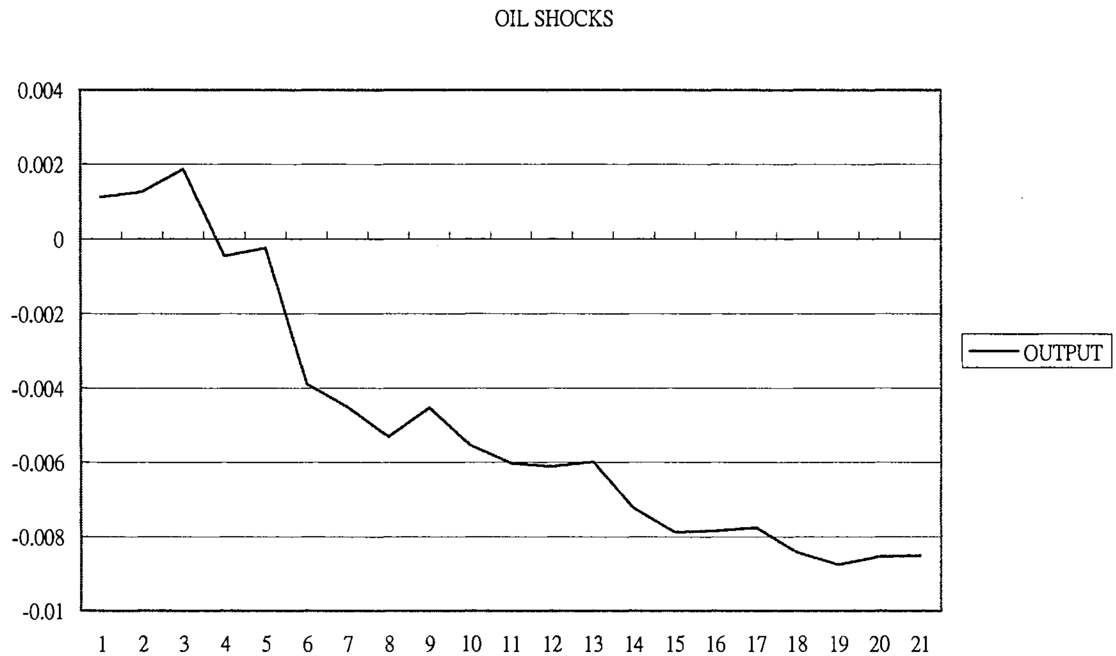


Figure 5-7 (b) Accumulated Response of Output to

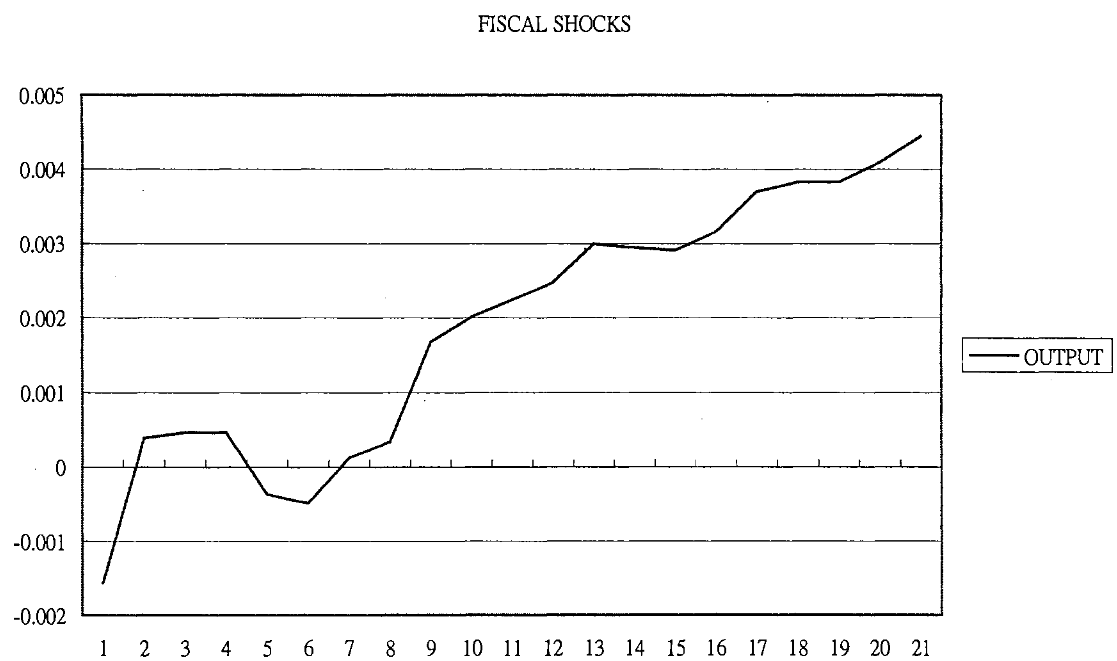


Figure 5-7 (c) Accumulated Response of Output to

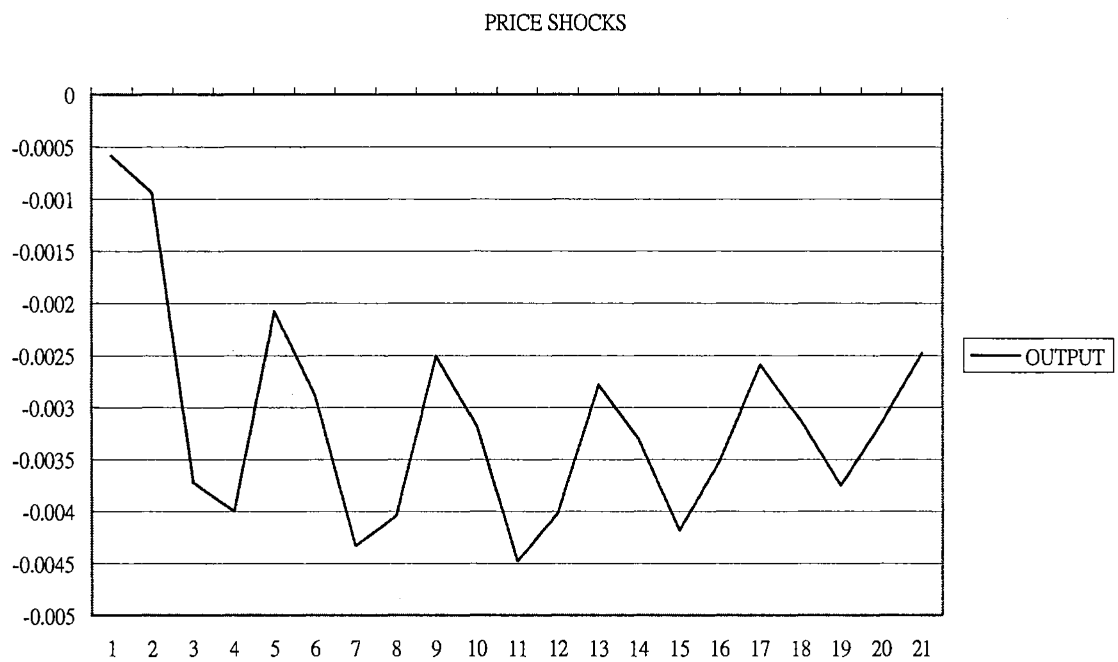


Figure 5-7 (d) Accumulated Response of Output to

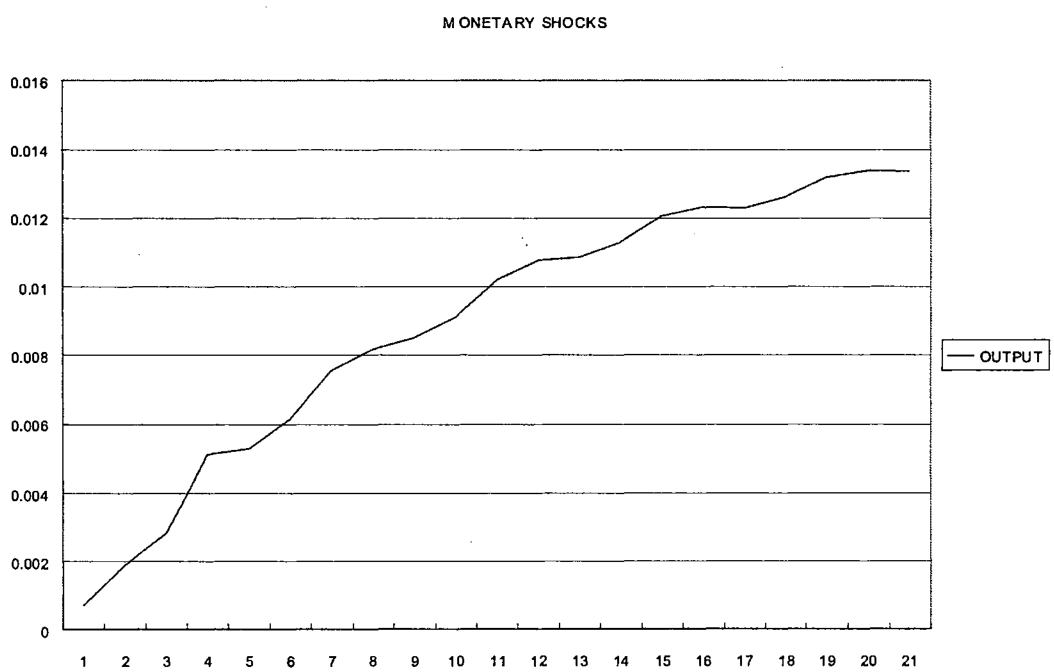


Figure 5-7 (e) Accumulated Response of Output to

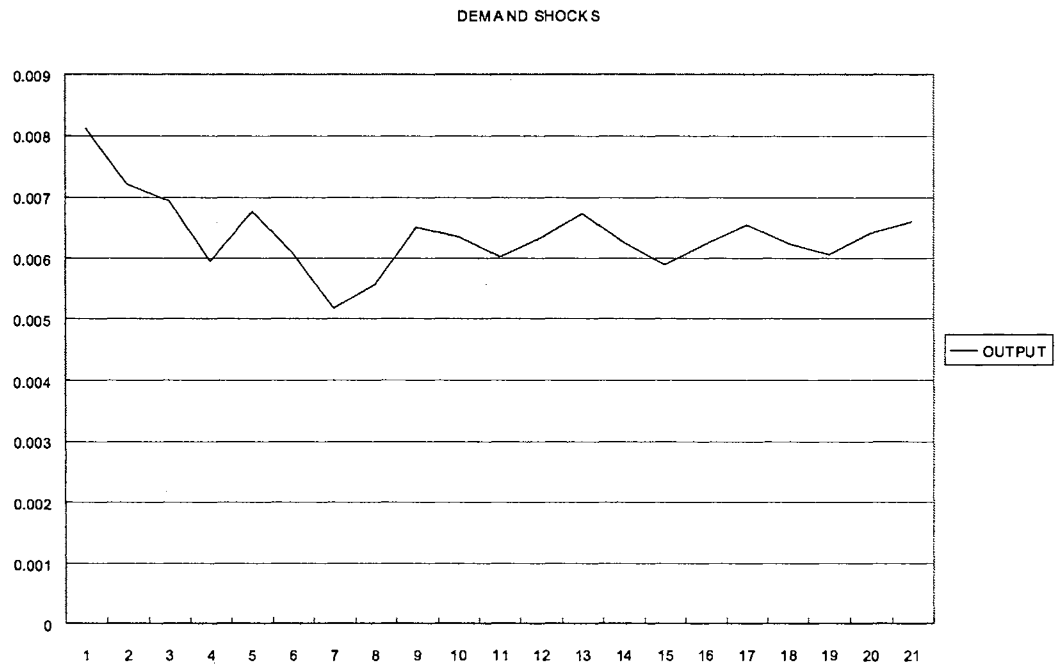


Figure 5-7 (f) Accumulated Response of Output to

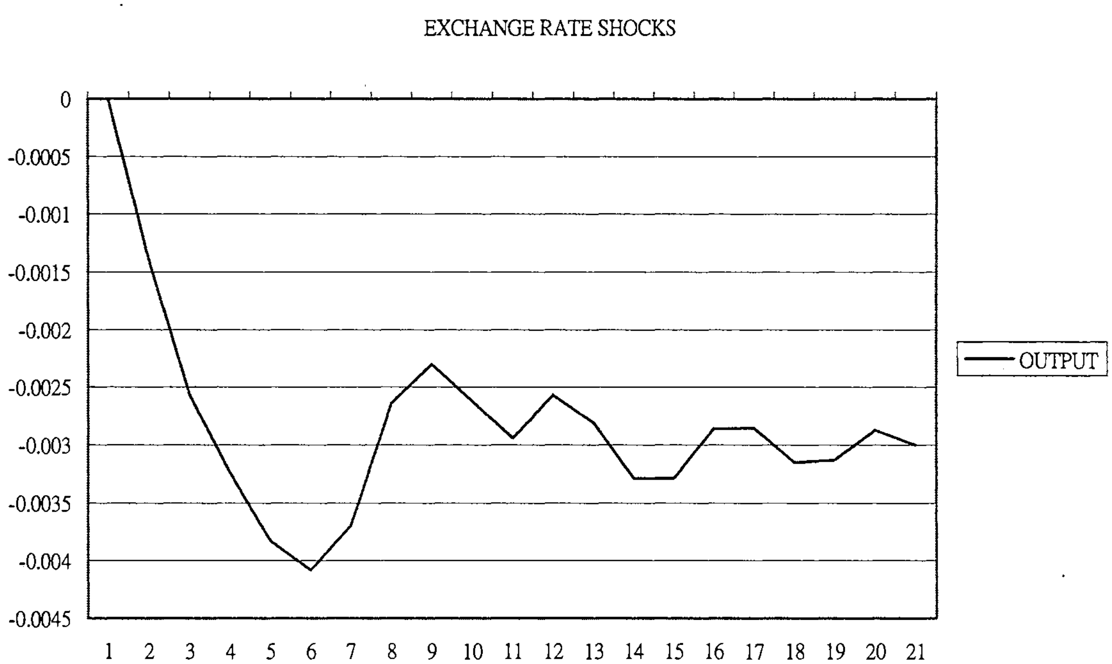


Figure 5-8 The Case of Taiwan (Choleski Decomposition)

Figure 5-8 (a) Accumulated Response of Price Level to

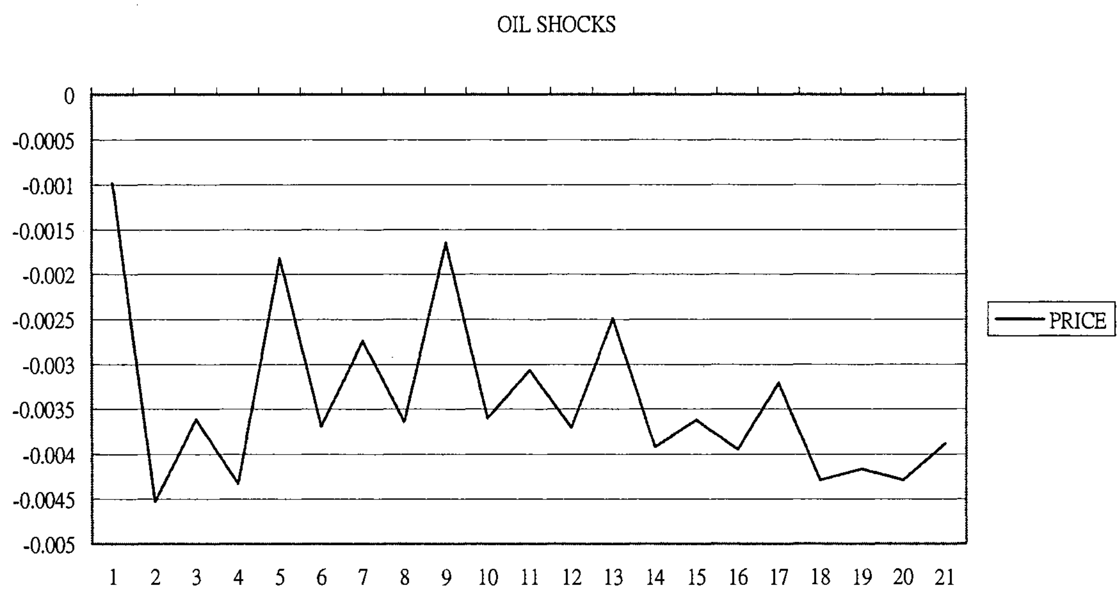


Figure 5-8 (b) Accumulated Response of Price Level to

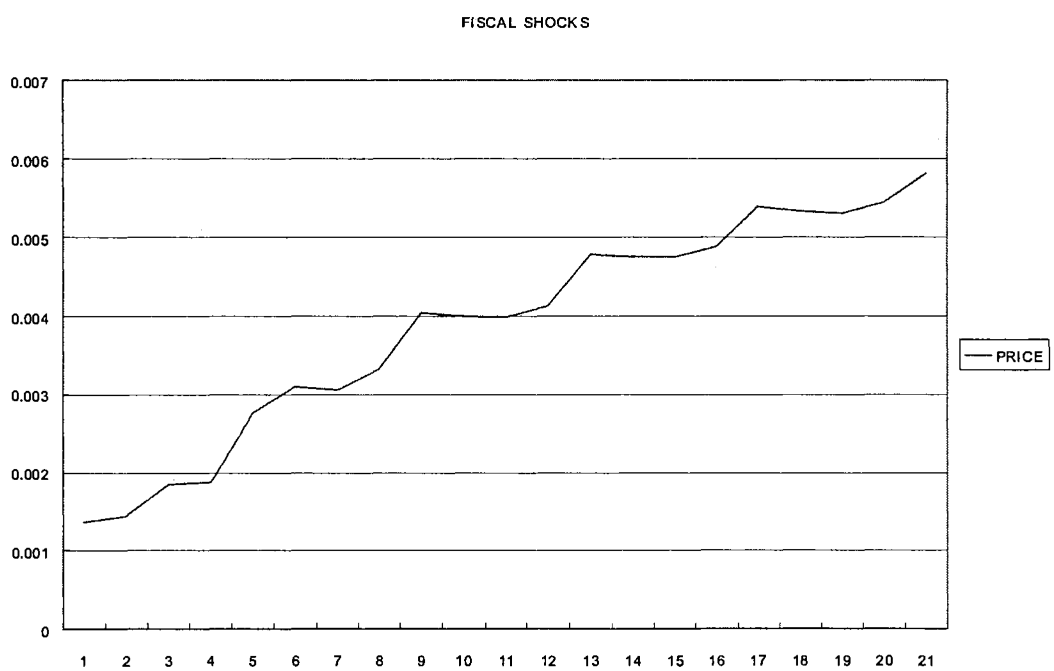


Figure 5-8 (c) Accumulated Response of Price Level to

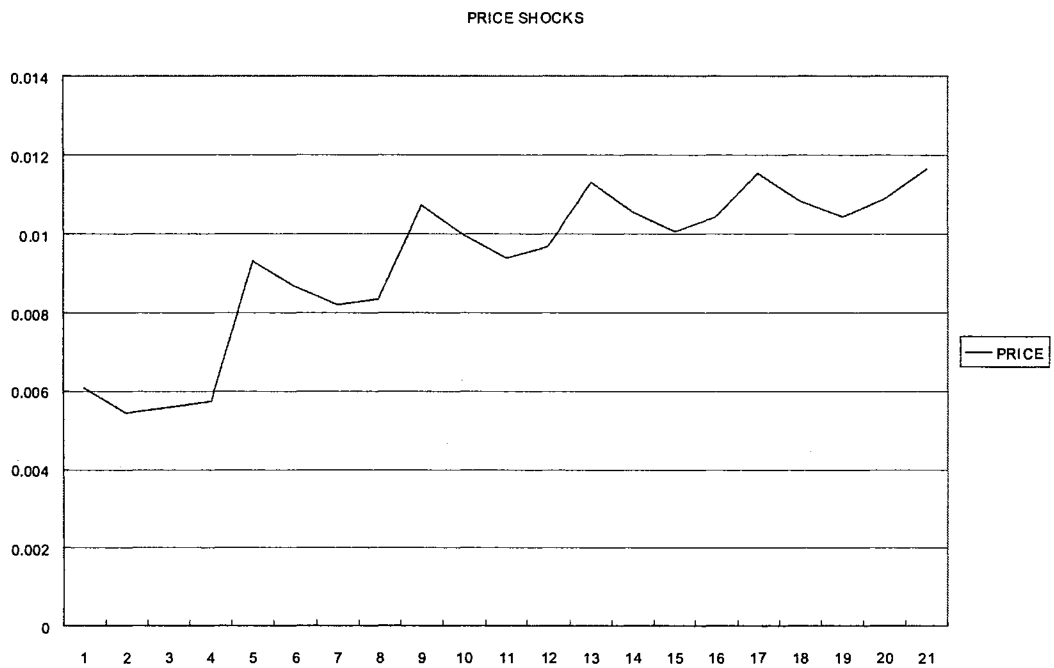


Figure 5-8 (d) Accumulated Response of Price Level to

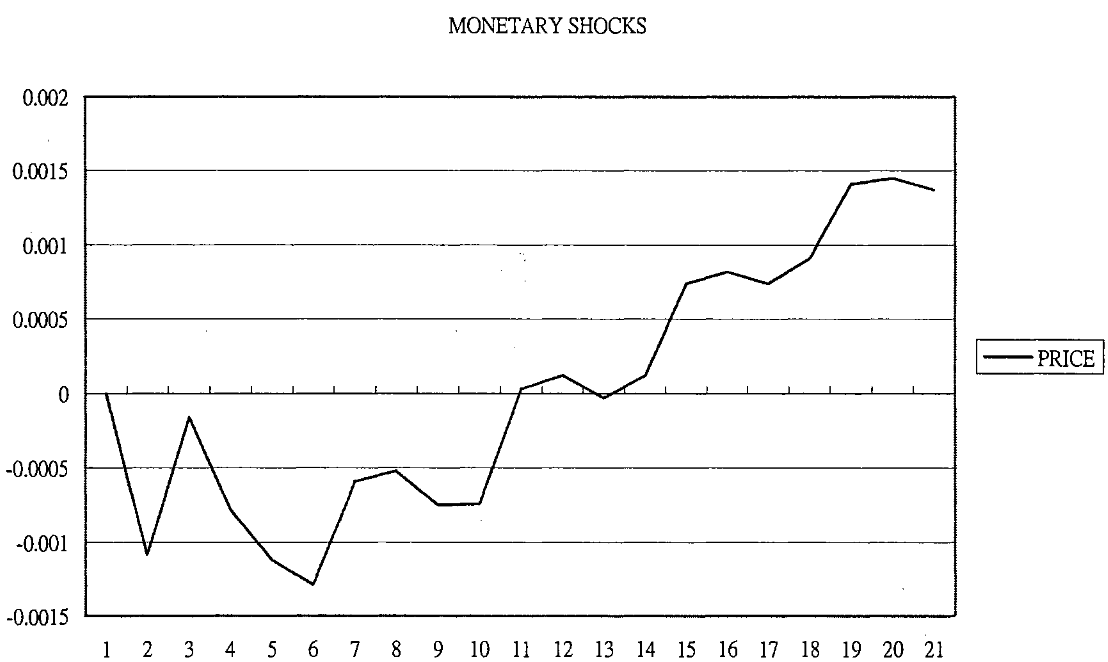


Figure 5-8 (e) Accumulated Response of Price Level to

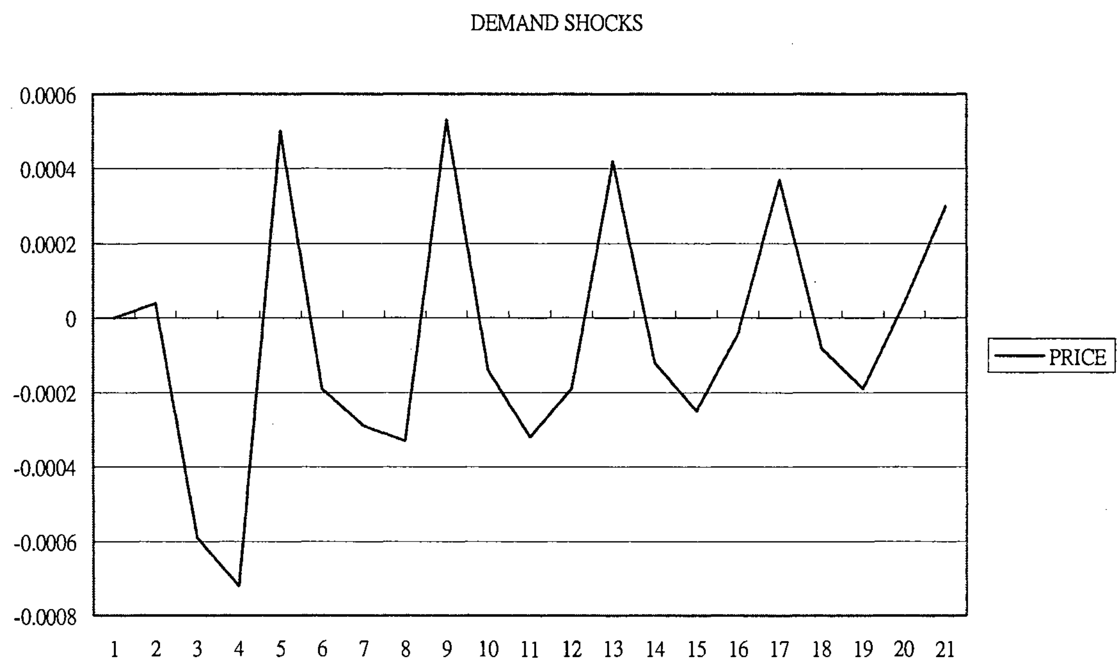


Figure 5-8 (f) Accumulated Response of Price Level to

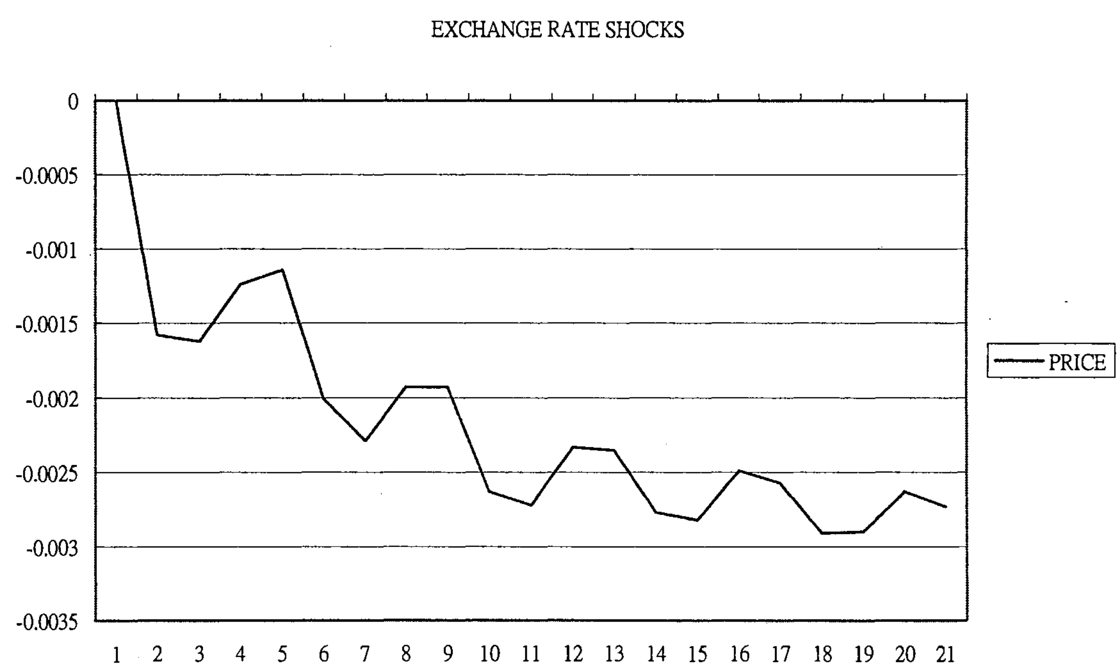


Figure 5-9 The Case of Taiwan (Choleski Decomposition)
Figure 5-9 (a) Accumulated Response of Exchange Rate to

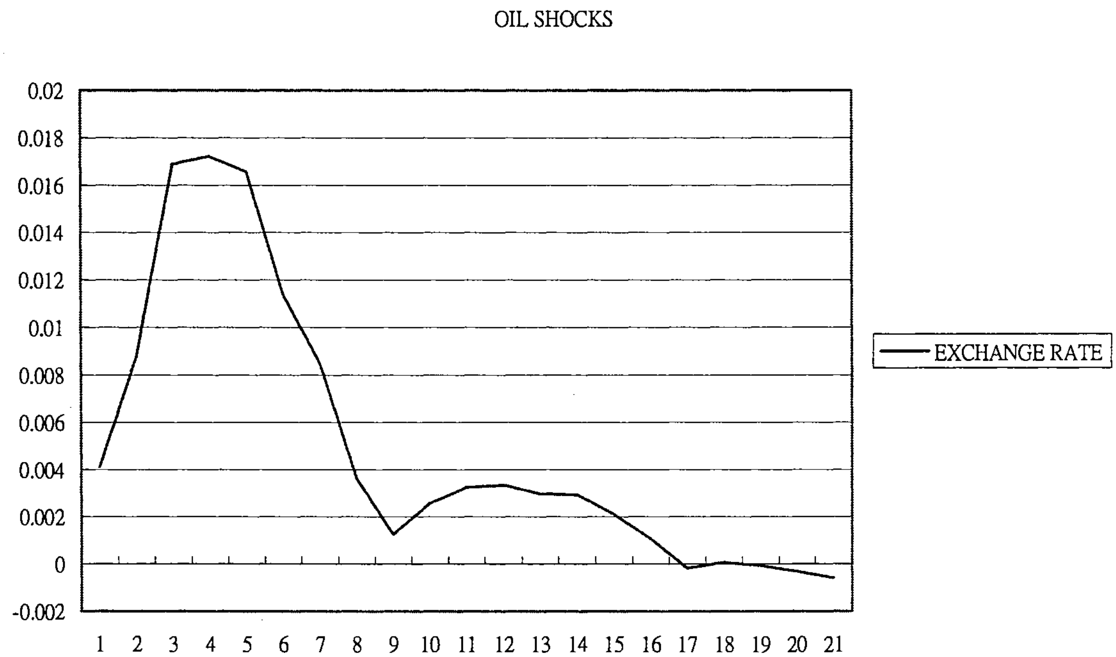


Figure 5-9 (b) Accumulated Response of Exchange Rate to

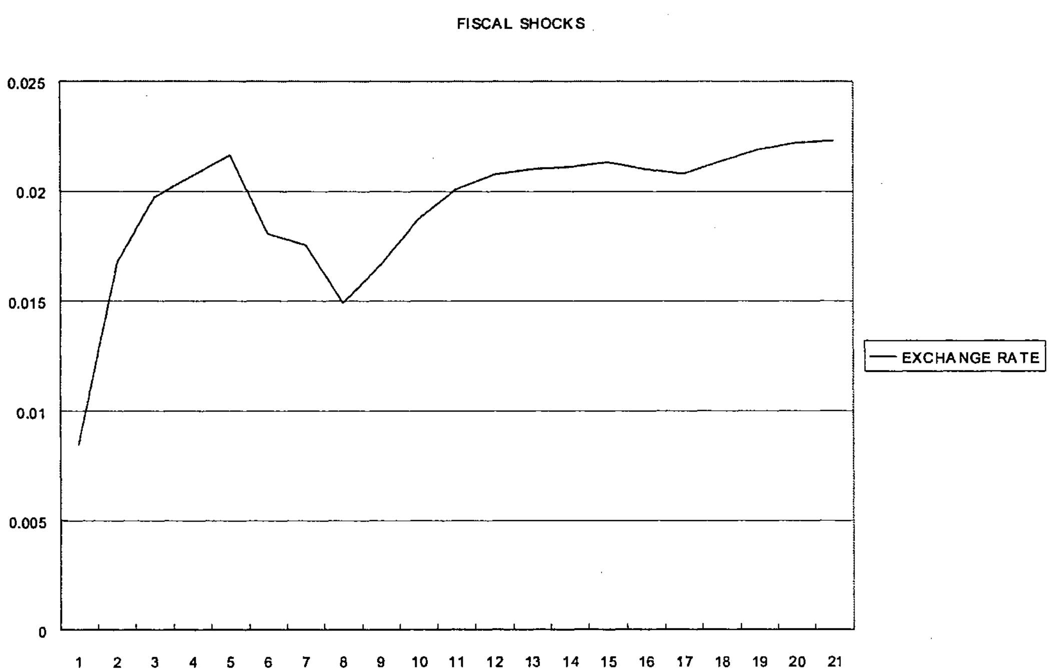


Figure 5-9 (c) Accumulated Response of Exchange Rate to

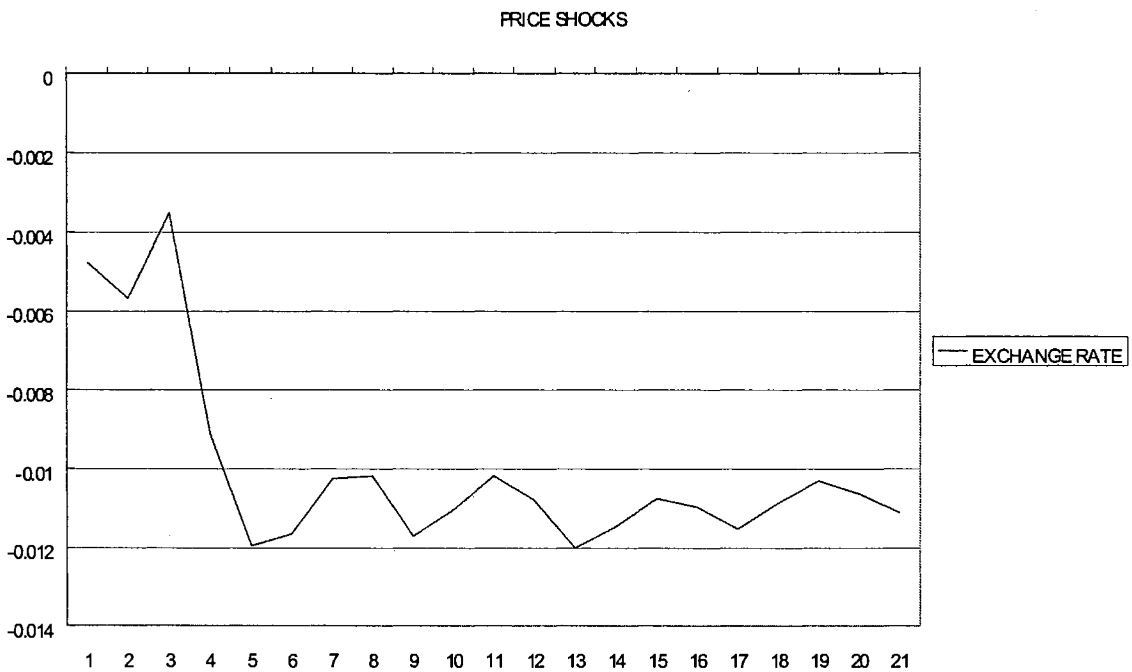


Figure 5-9 (d) Accumulated Response of Exchange Rate to

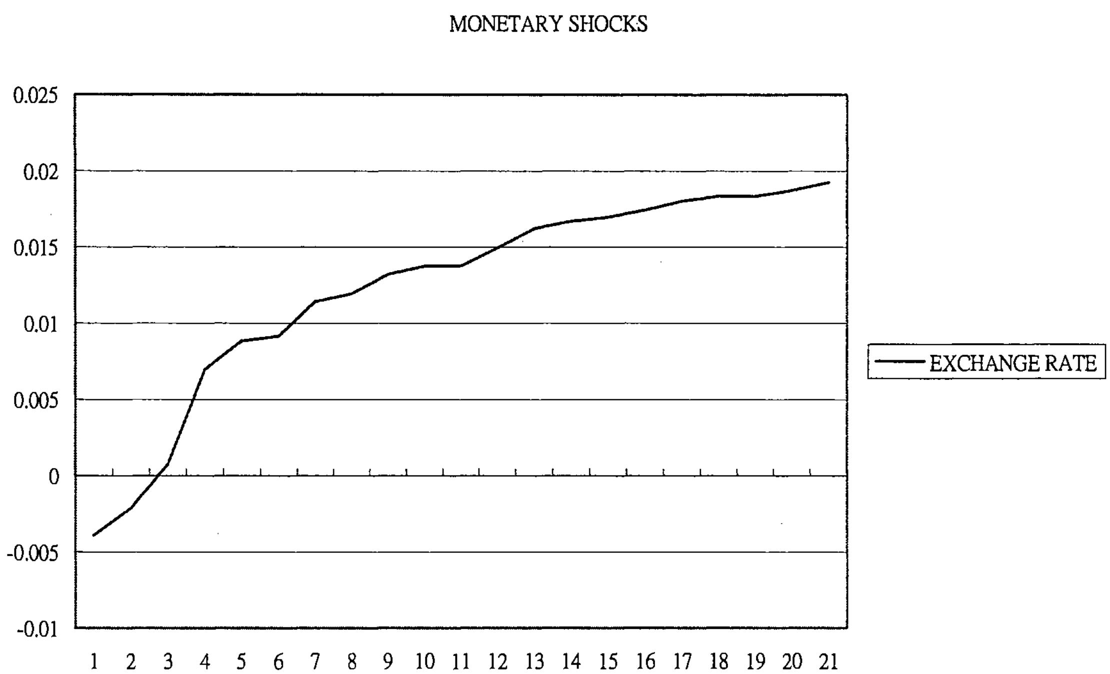


Figure 5-9 (e) Accumulated Response of Exchange Rate to

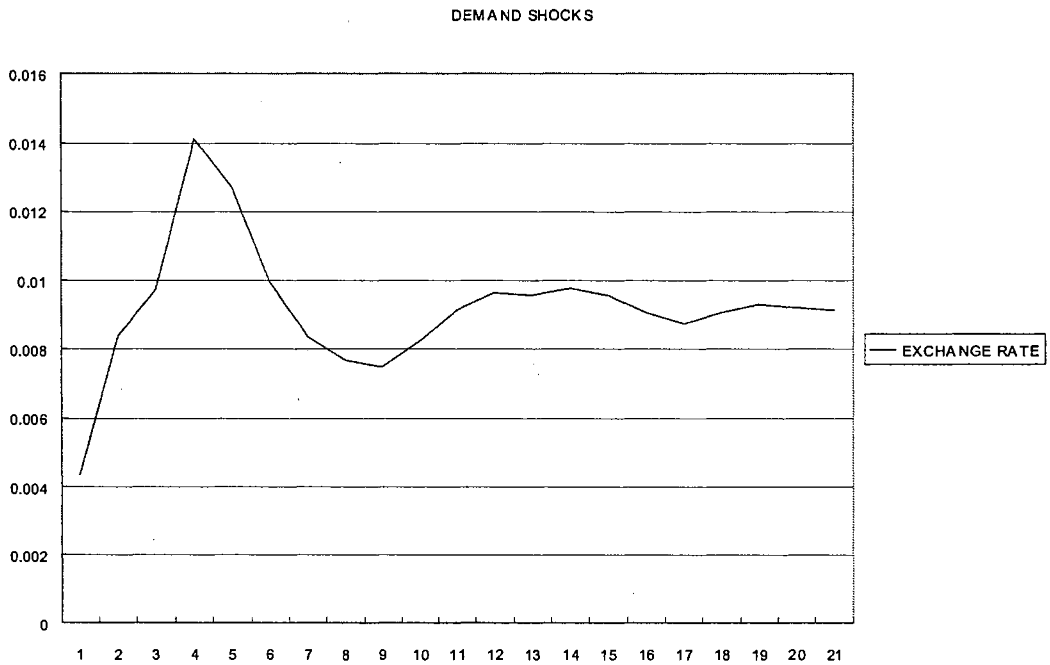


Figure 5-9 (f) Accumulated Response of Exchange Rate to

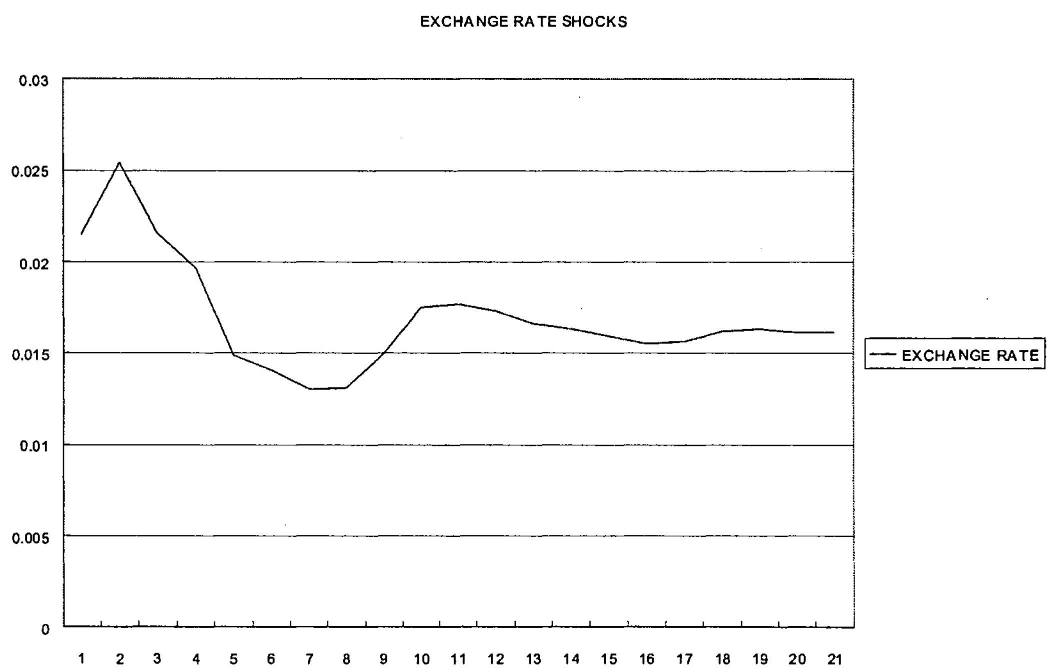


Figure 5-10 Identified Structural Shocks for Restricted Karras Model

Figure 5-10 (a) Structural Oil Shocks

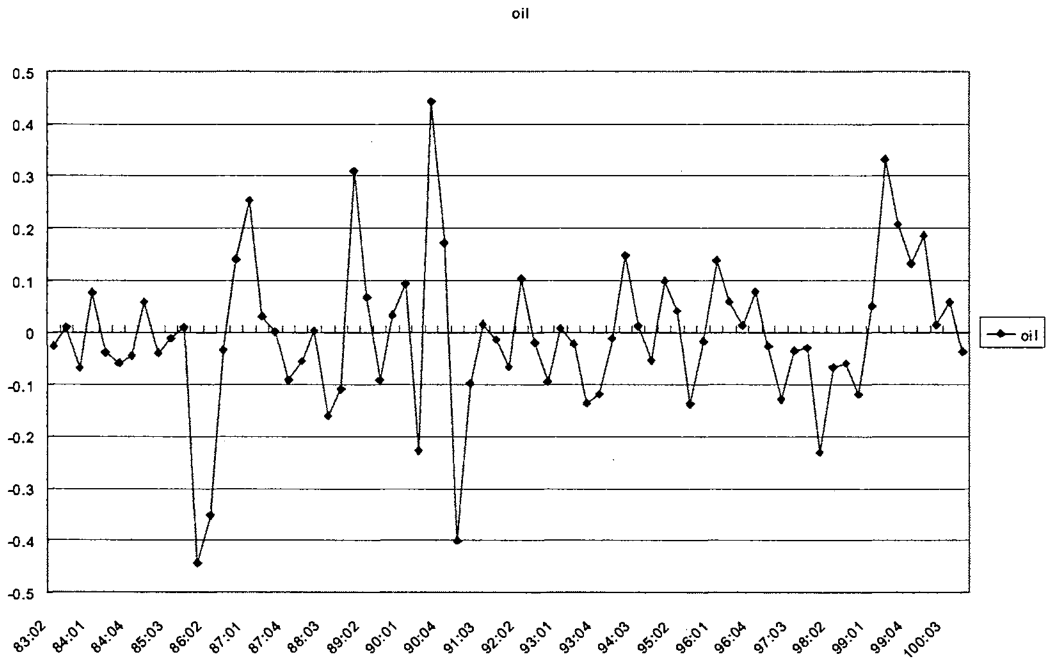


Figure 5-10 (b) Structural Fiscal Shocks

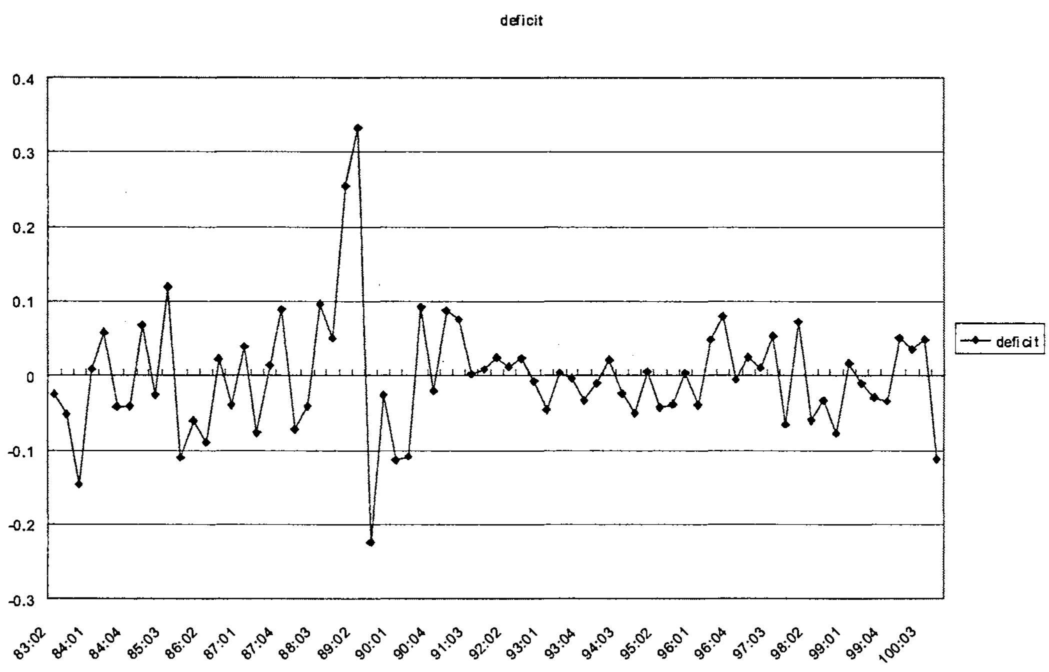


Figure 5-10 (c) Structural Price Shocks

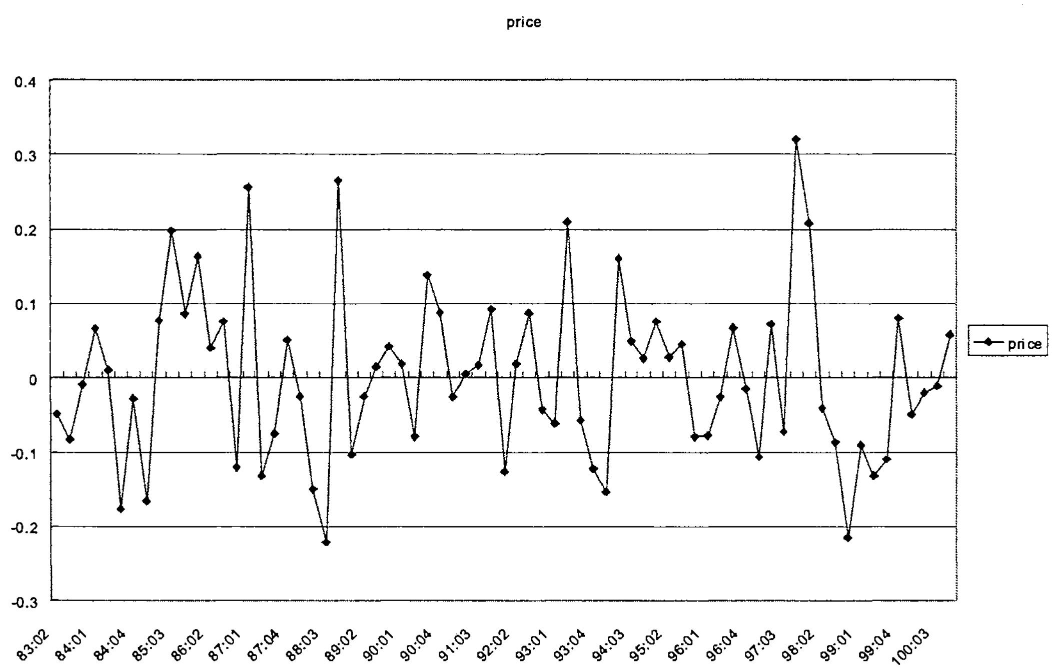


Figure 5-10 (d) Structural Monetary Shocks

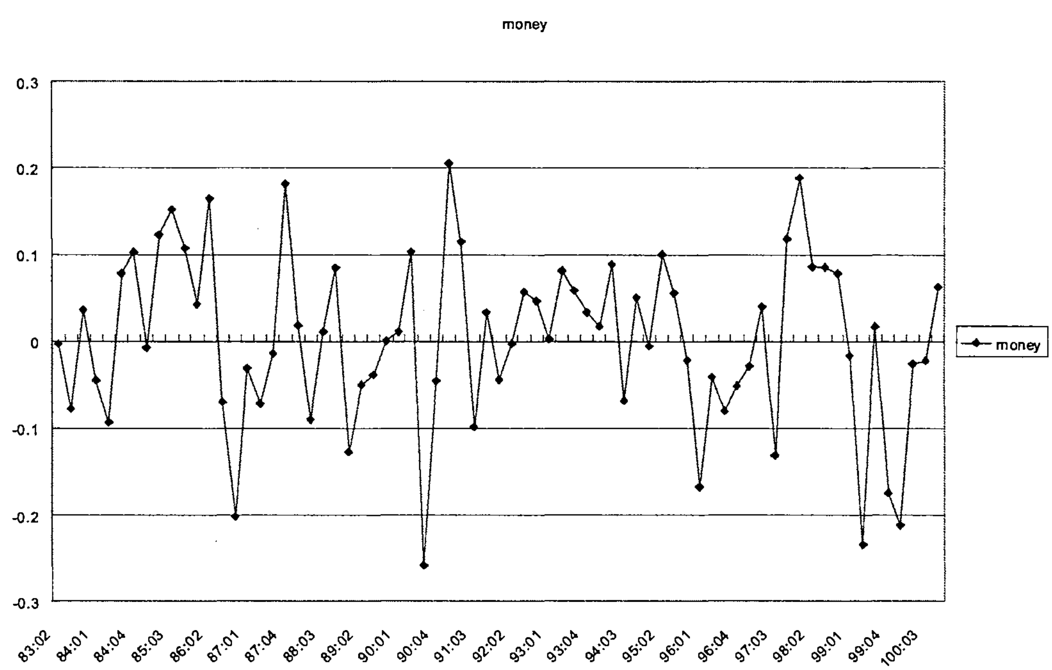


Figure 5-10 (e) Structural Demand Shocks

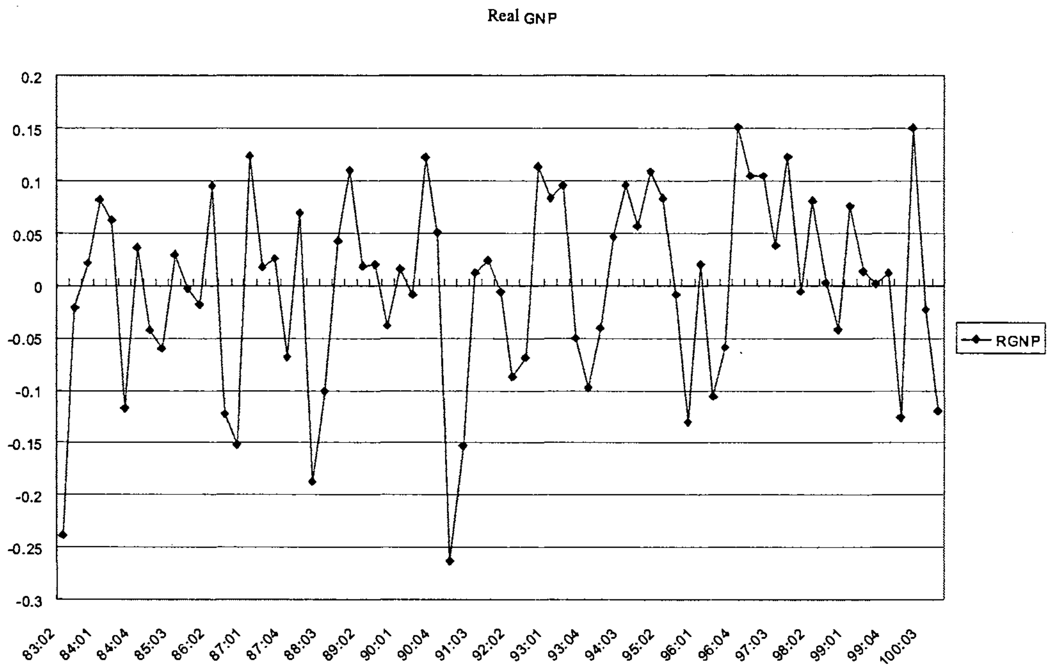


Figure 5-10 (f) Structural Exchange Rate Shocks

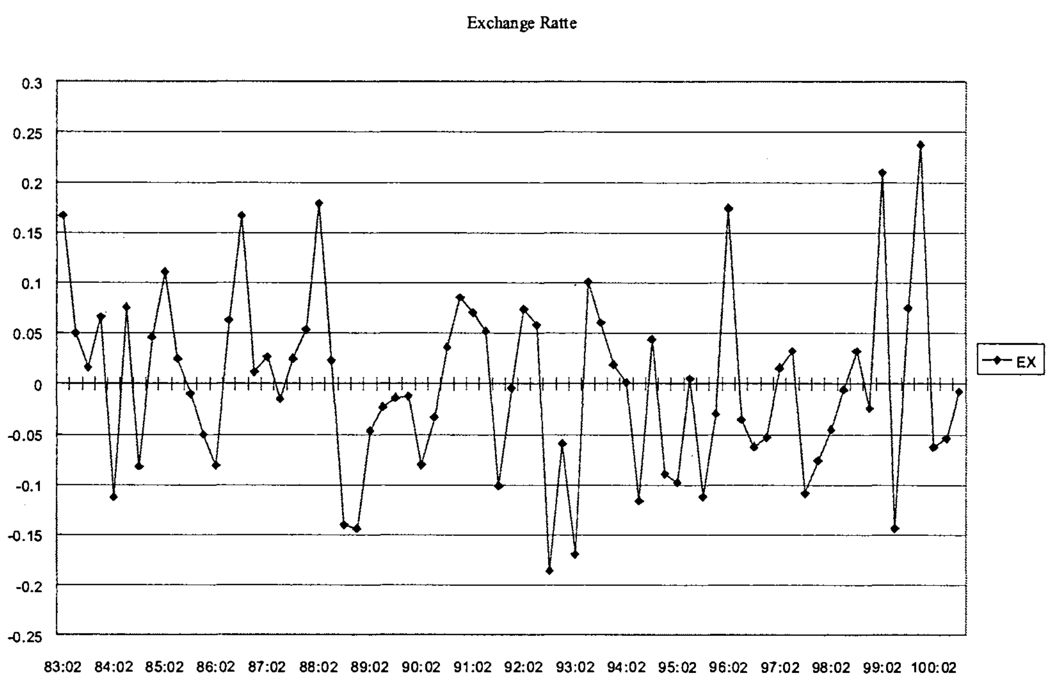


Figure 6-1 The Case of Japan (Restricted Karras Model)

Figure 6-1 (a) Accumulated Response of Output to

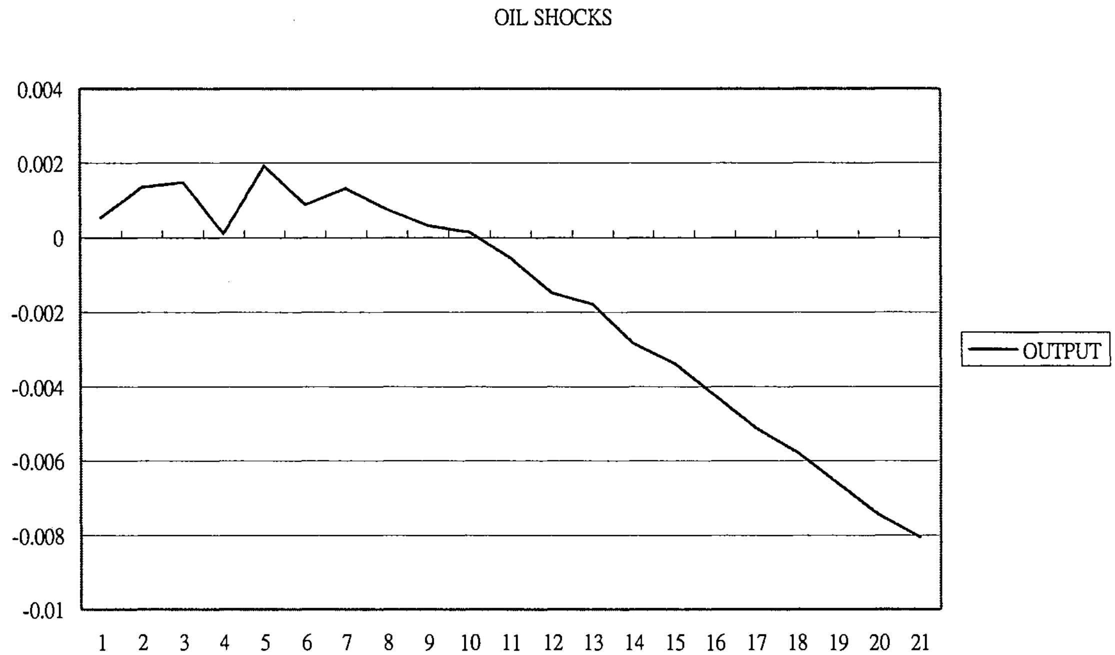


Figure 6-1 (b) Accumulated Response of Output to

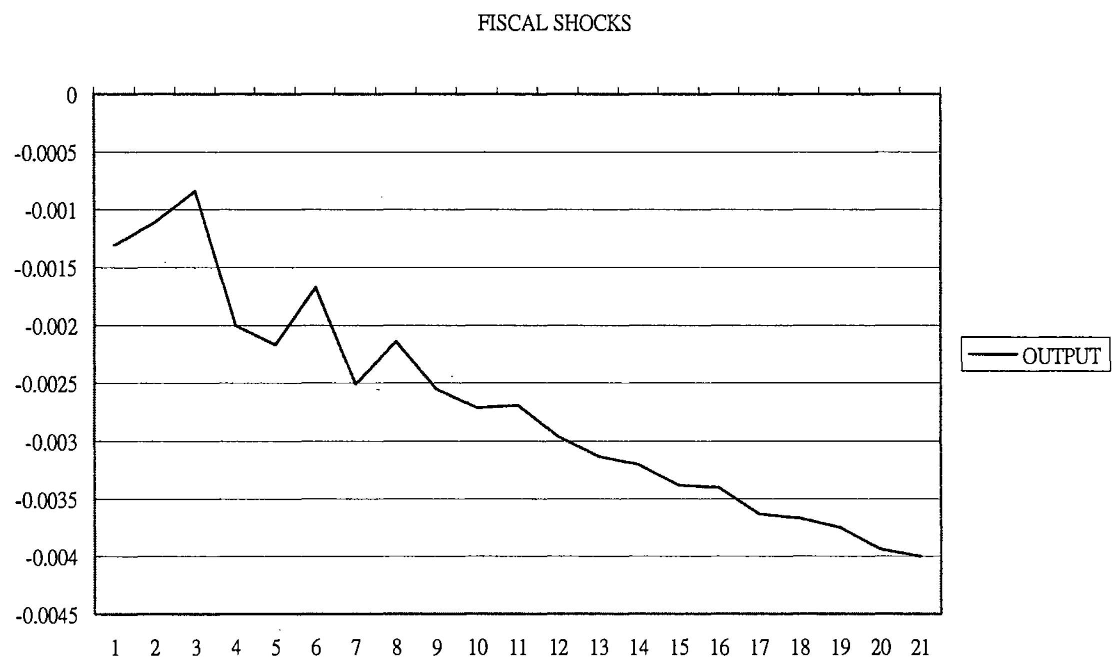


Figure 6-1 (c) Accumulated Response of Output to

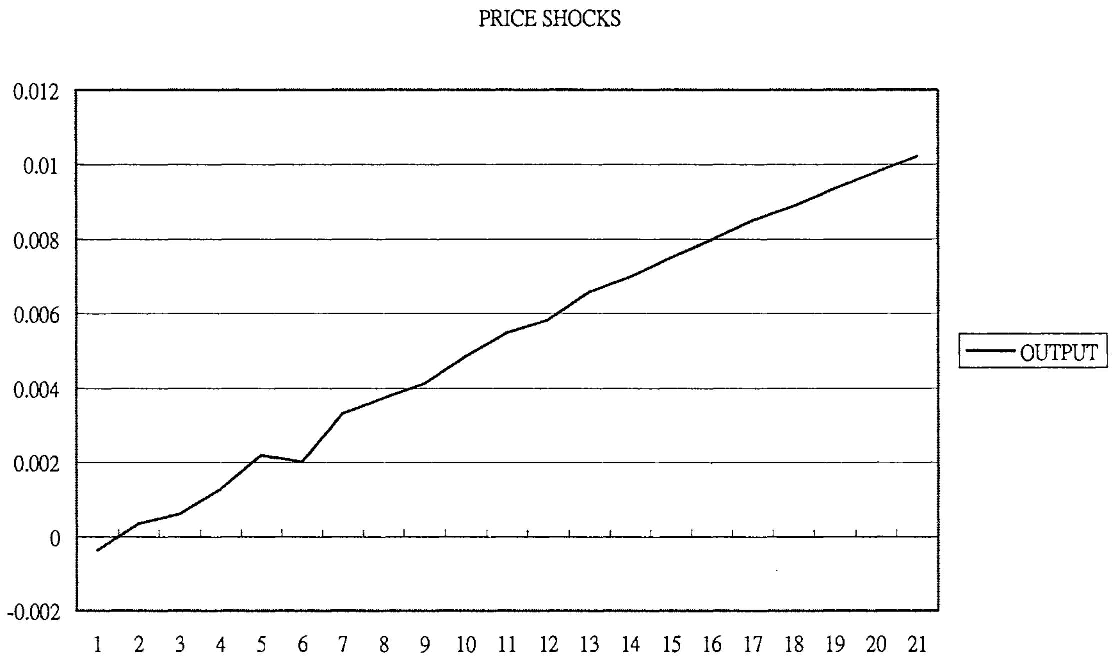


Figure 6-1 (d) Accumulated Response of Output to

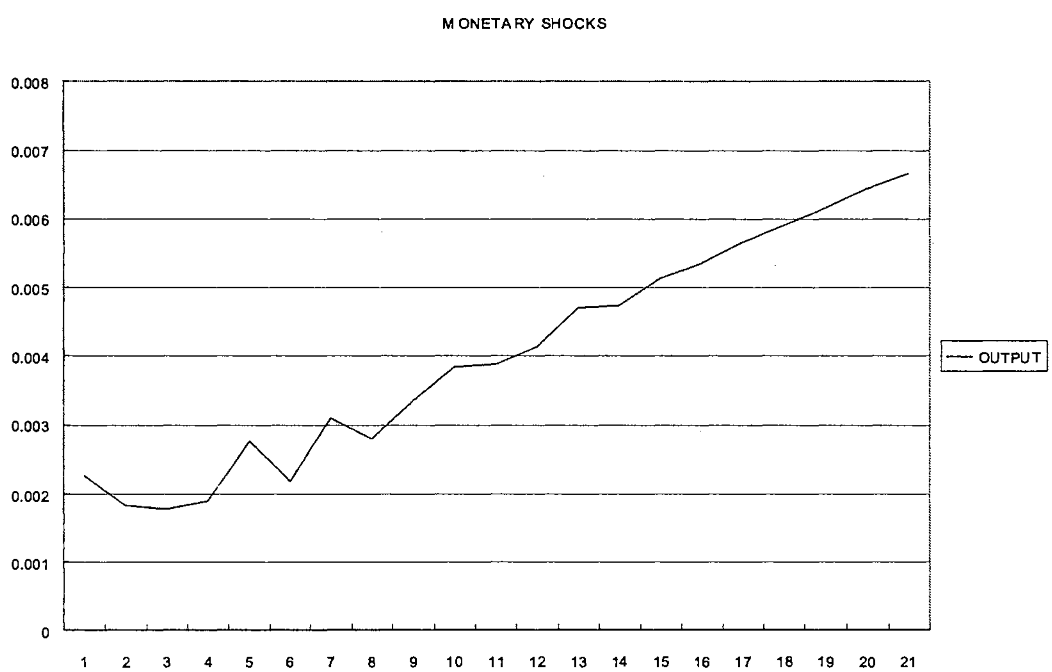


Figure 6-1 (e) Accumulated Response of Output to

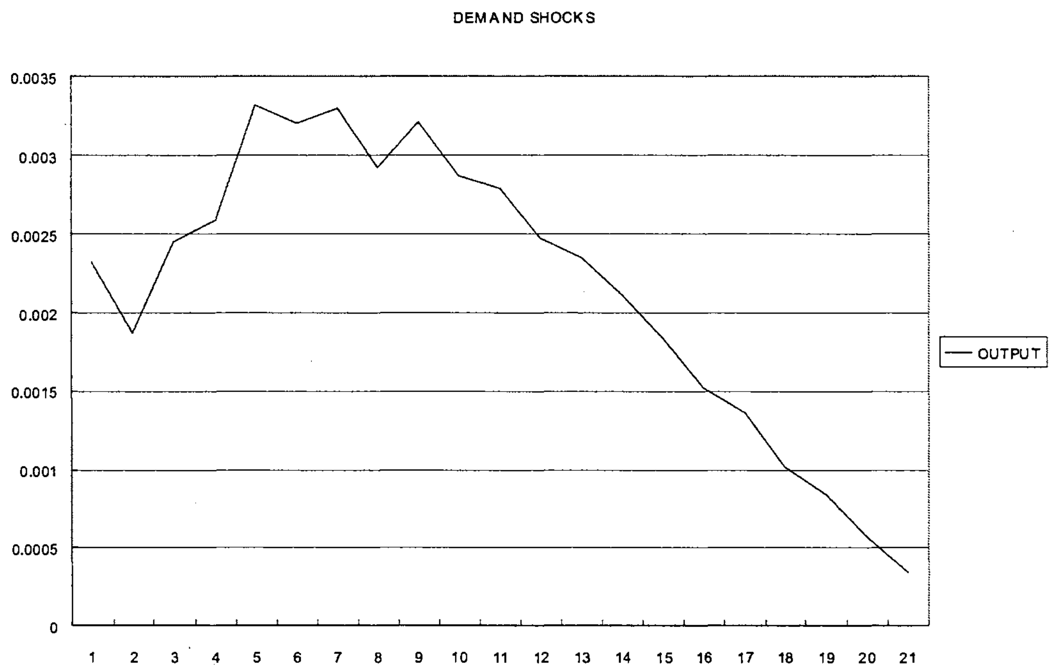


Figure 6-1 (f) Accumulated Response of Output to

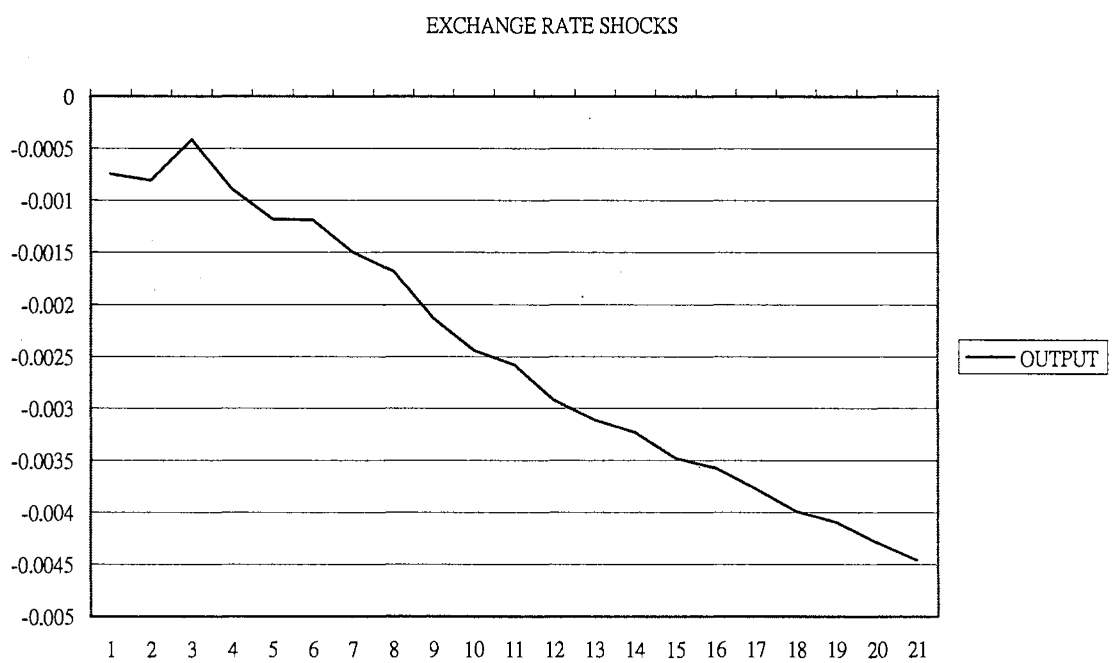


Figure 6-2 The Case of Japan (Restricted Karras Model)

Figure 6-2 (a) Accumulated Response of Price Level to

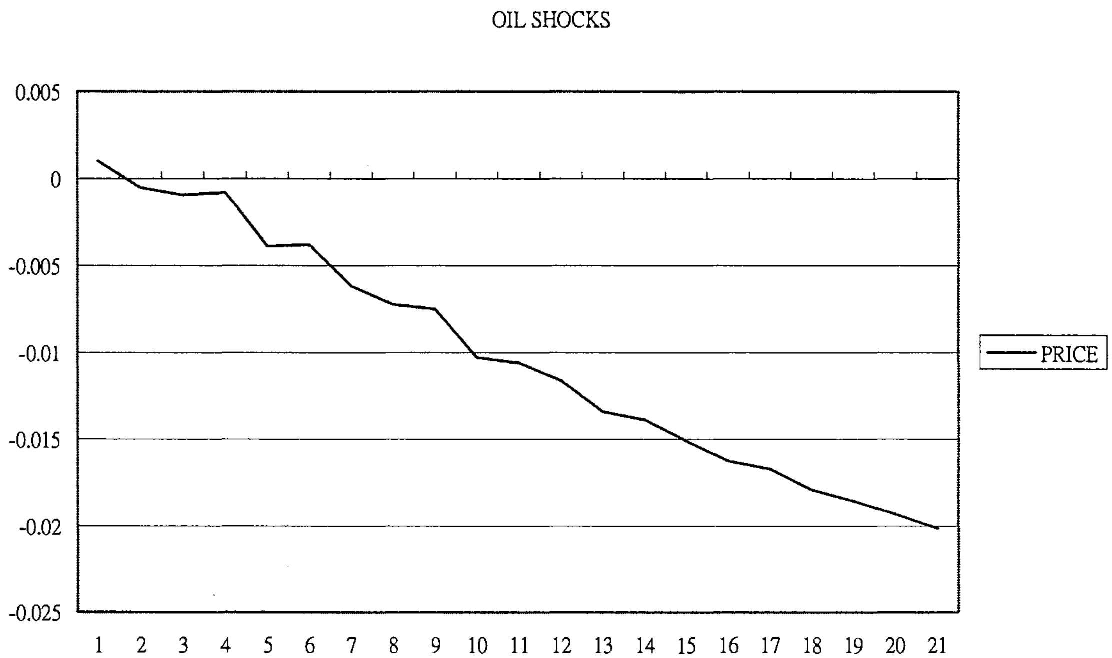


Figure 6-2 (b) Accumulated Response of Price Level to

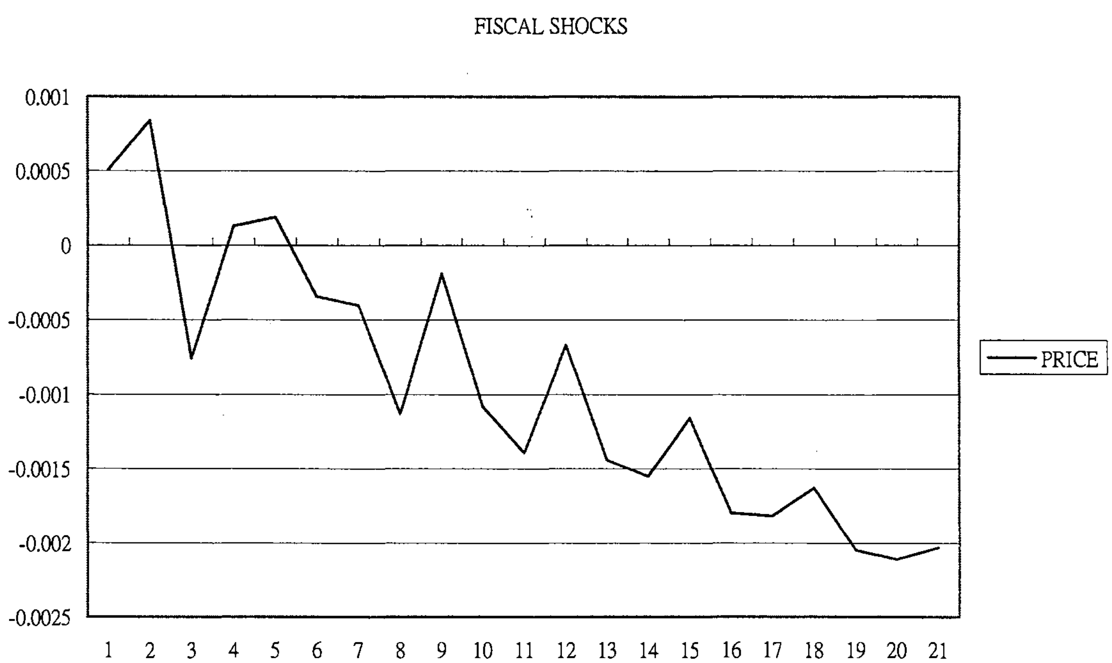


Figure 6-2 (c) Accumulated Response of Price Level to

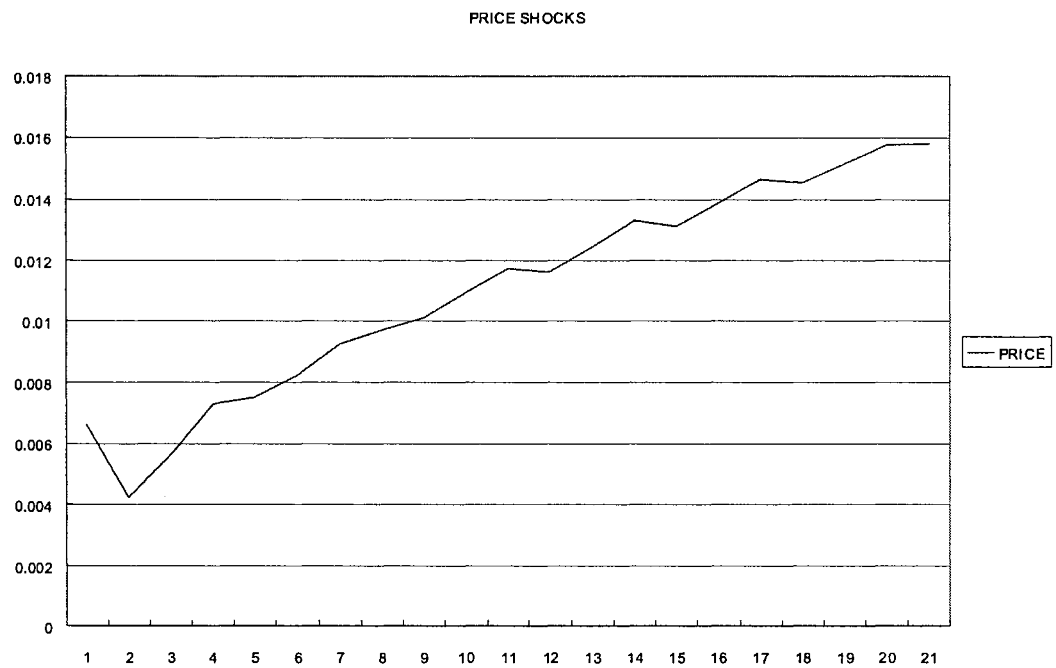


Figure 6-2 (d) Accumulated Response of Price Level to

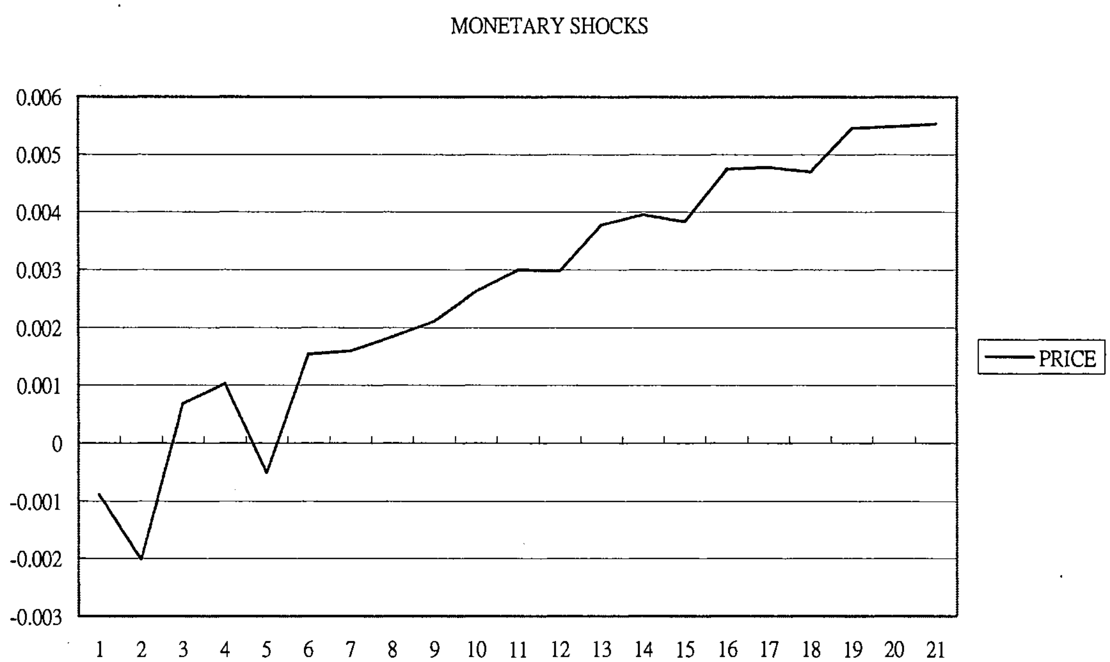


Figure 6-2 (e) Accumulated Response of Price Level to

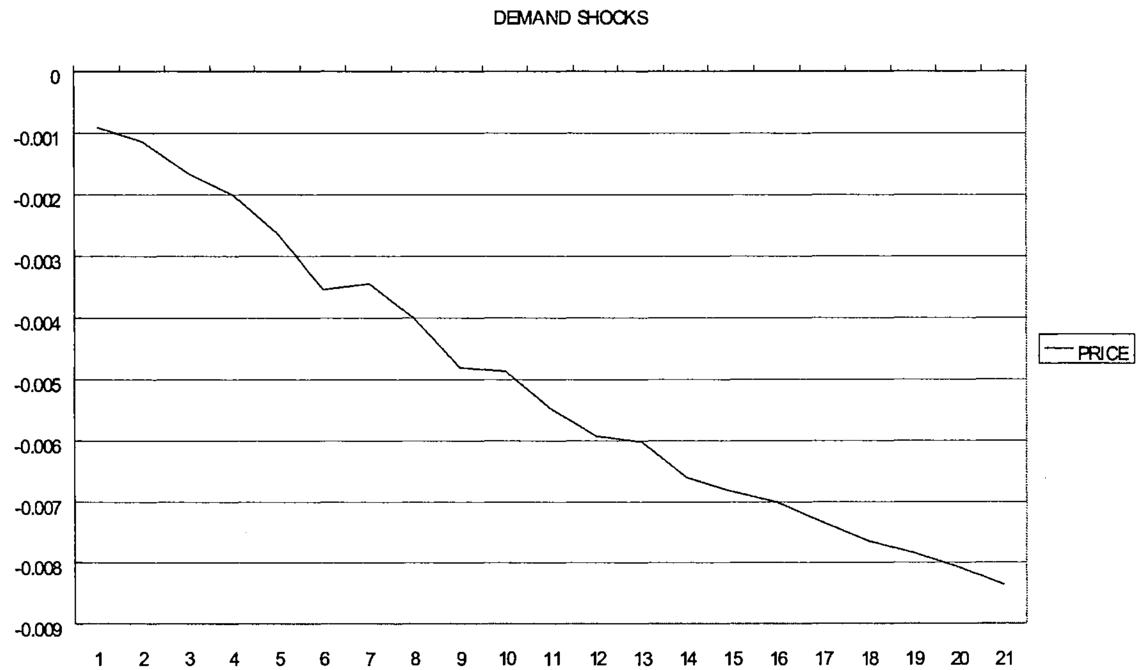


Figure 6-2 (f) Accumulated Response of Price Level to

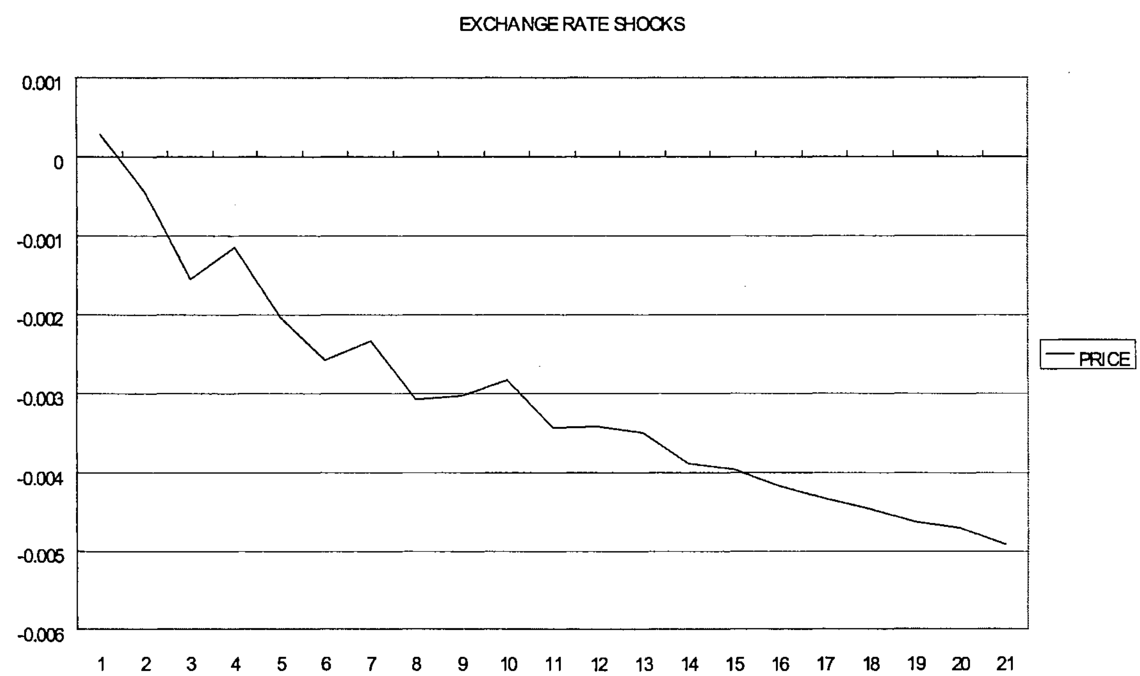


Figure 6-3 The Case of Japan (Restricted Karras Model)

Figure 6-3 (a) Accumulated Response of Exchange Rate to

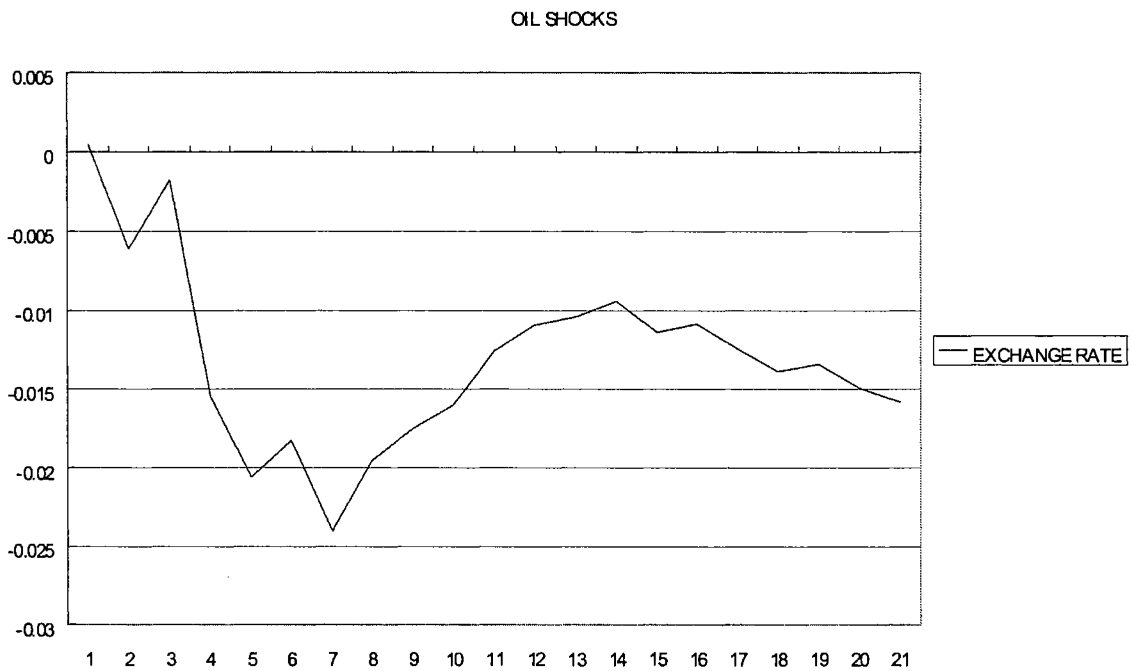


Figure 6-3 (b) Accumulated Response of Exchange Rate to

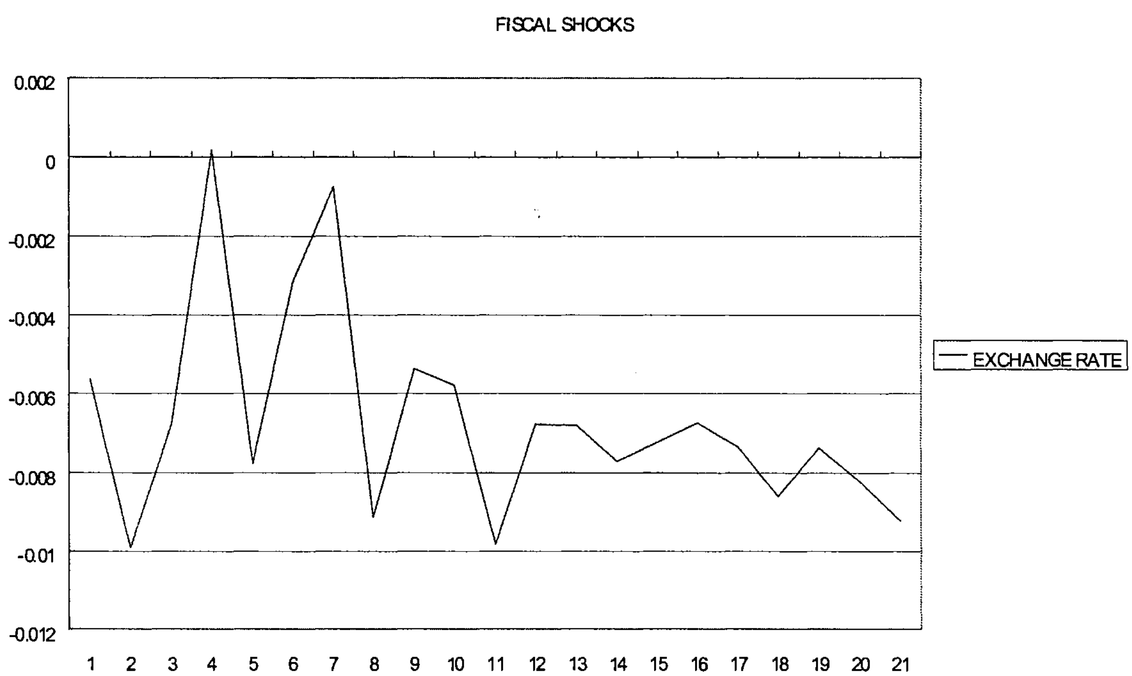


Figure 6-3 (c) Accumulated Response of Exchange Rate to

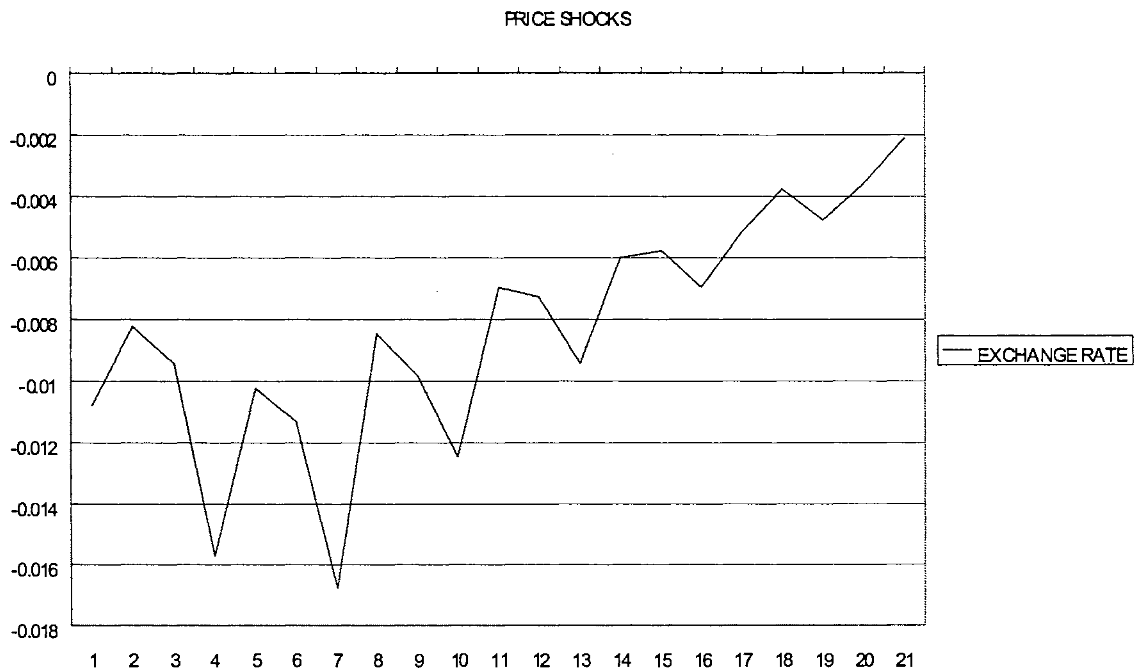


Figure 6-3 (d) Accumulated Response of Exchange Rate to

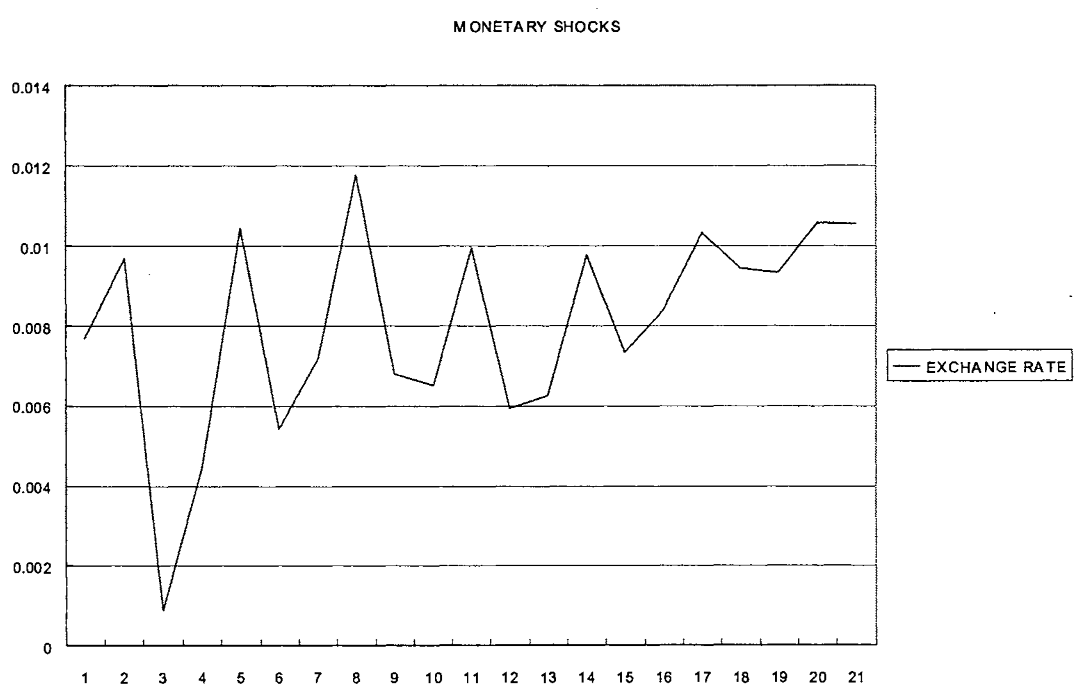


Figure 6-3 (e) Accumulated Response of Exchange Rate to

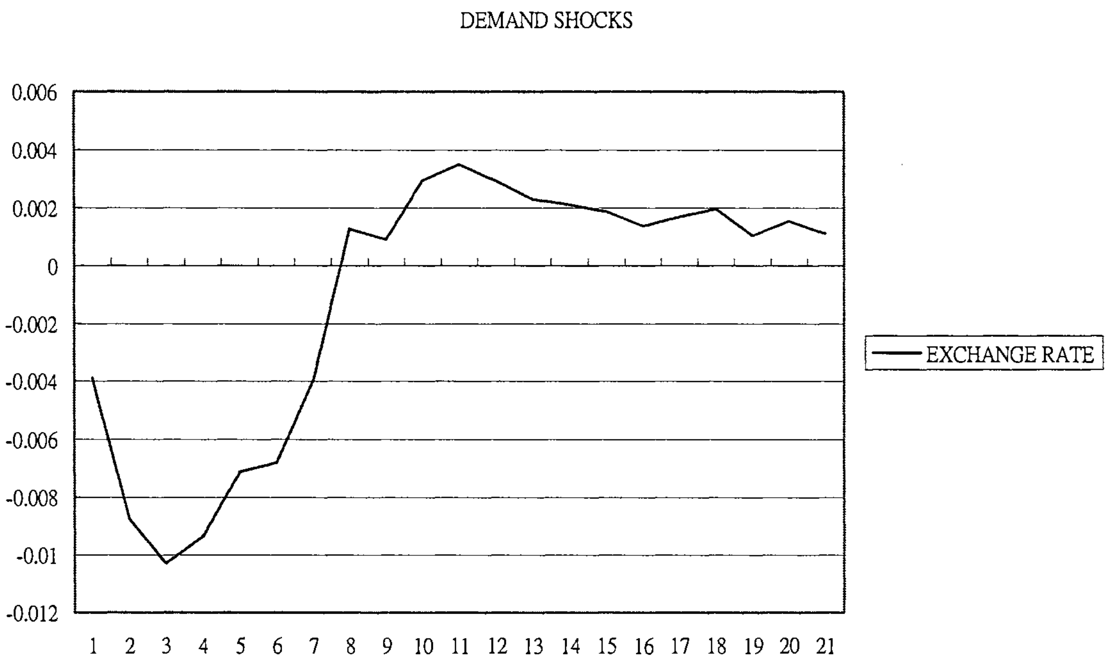


Figure 6-3 (f) Accumulated Response of Exchange Rate to

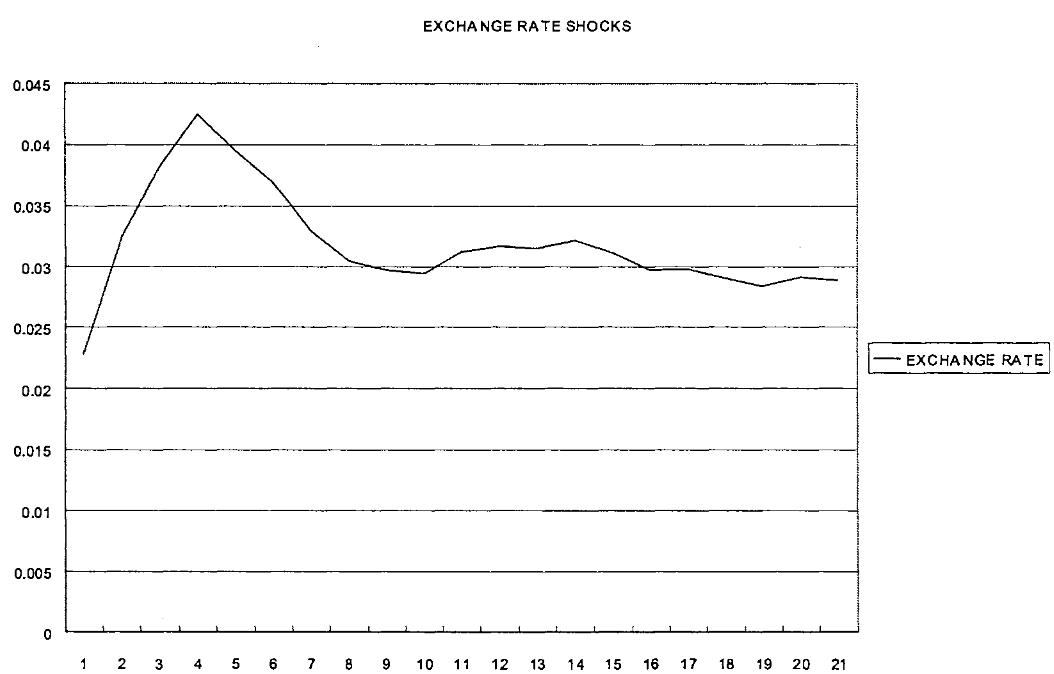


Figure 7-1 The Case of Korea (Restricted Karras Model)

Figure 7-1 (a) Accumulated Response of Output to

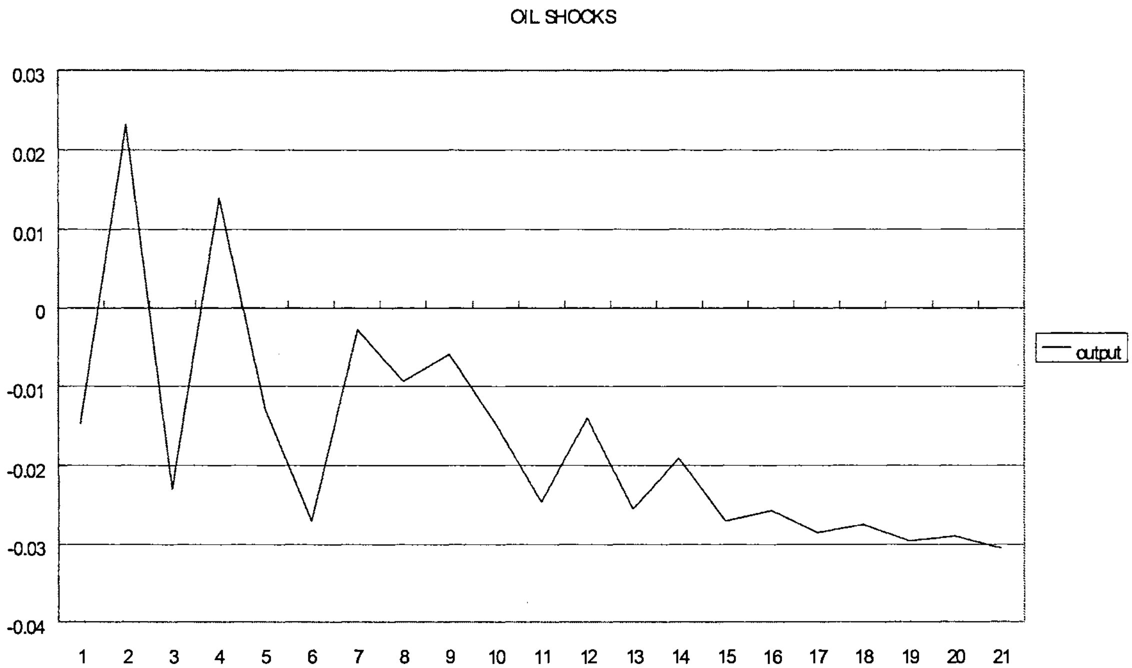


Figure 7-1 (b) Accumulated Response of Output to

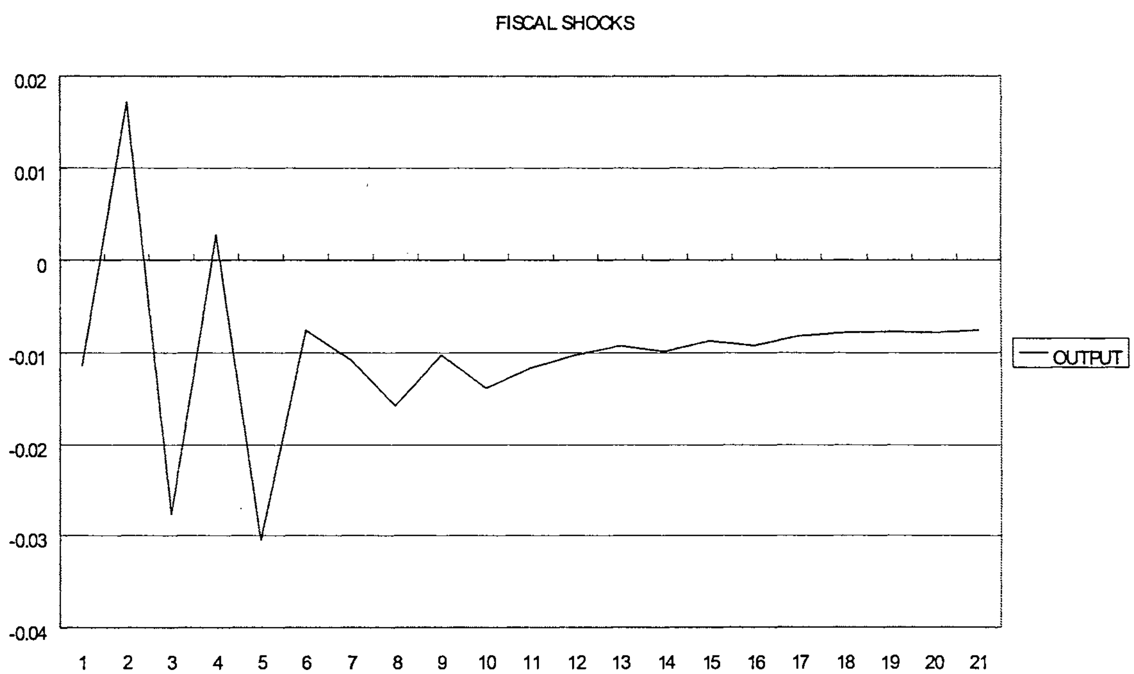


Figure 7-1 (c) Accumulated Response of Output to

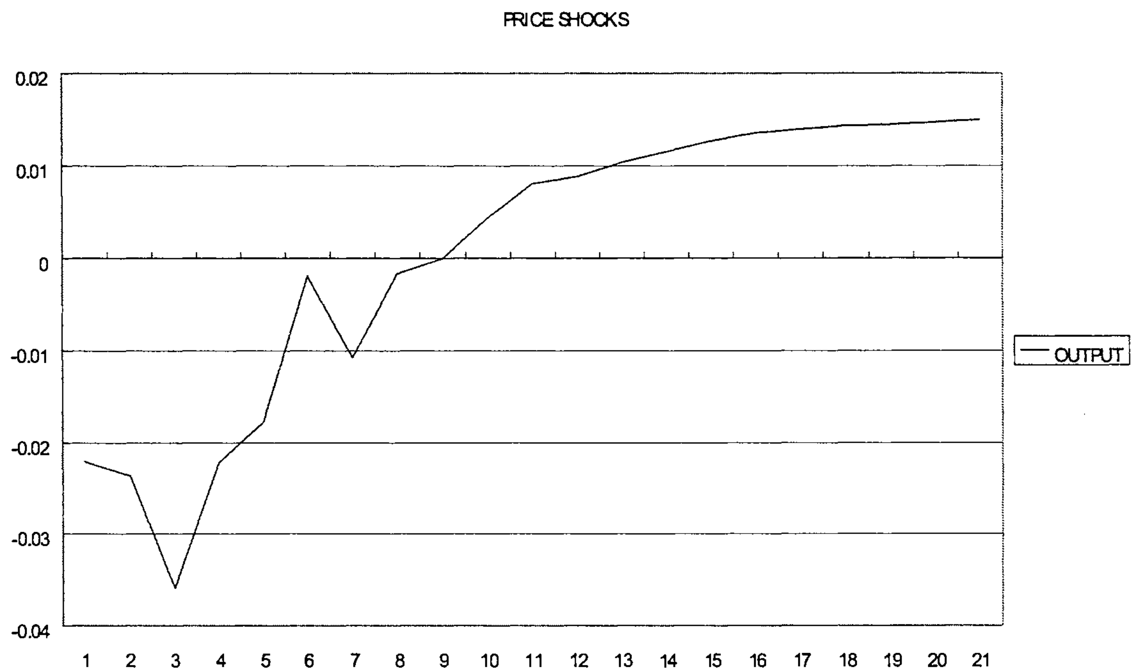


Figure 7-1 (d) Accumulated Response of Output to

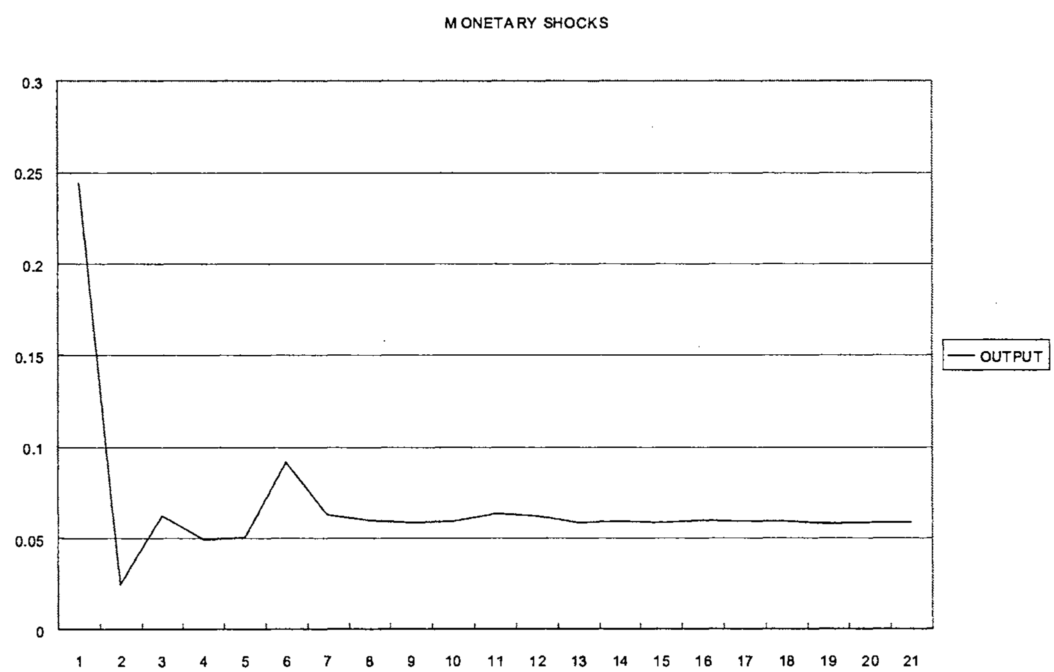


Figure 7-1 (e) Accumulated Response of Output to

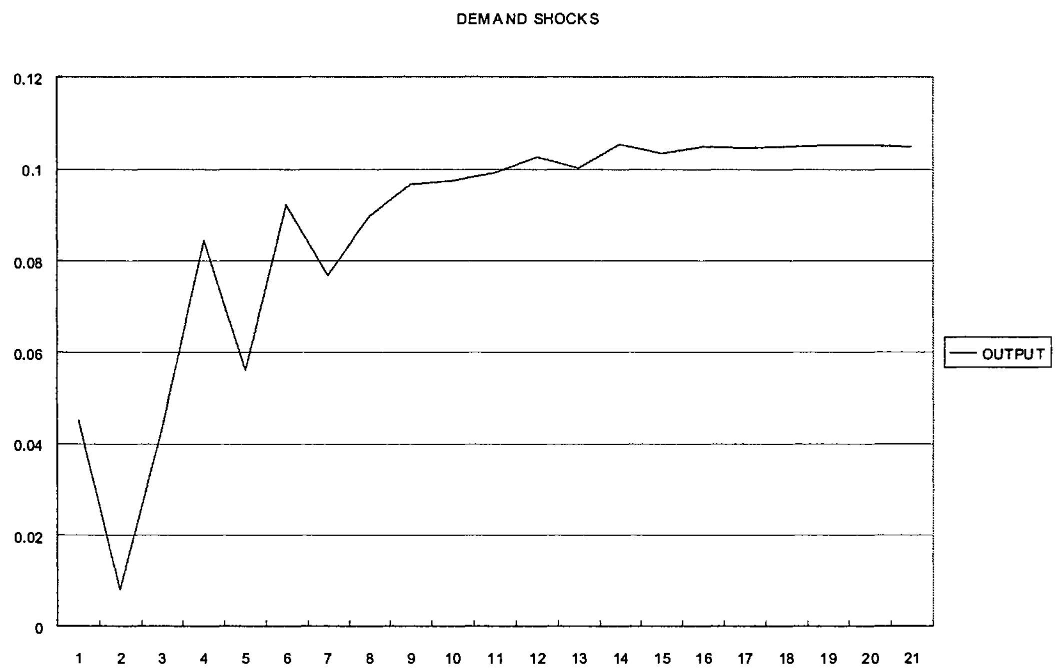


Figure 7-1 (f) Accumulated Response of Output to

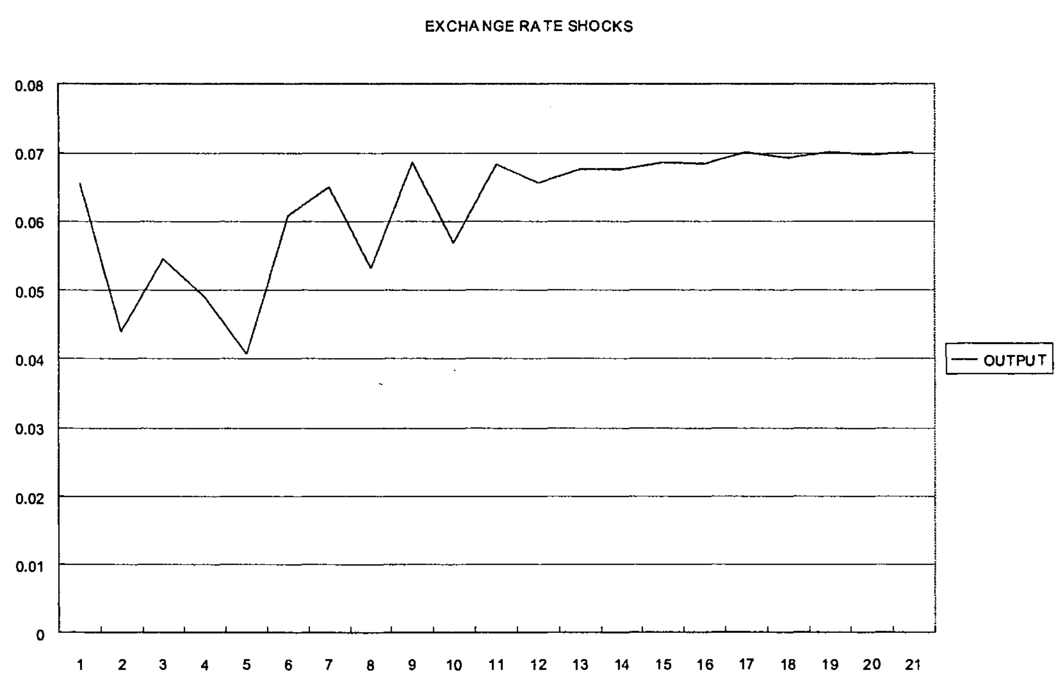


Figure 7-2 The Case of Korea (Restricted Karras Model)

Figure 7-2 (a) Accumulated Response of Price Level to

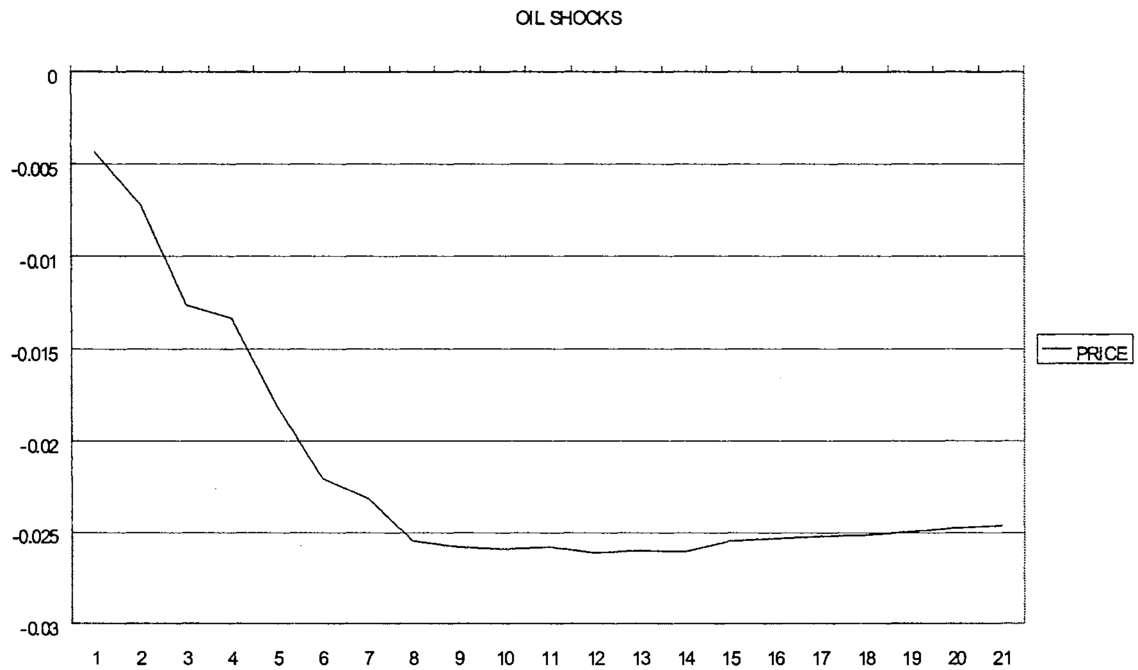


Figure 7-2 (b) Accumulated Response of Price Level to

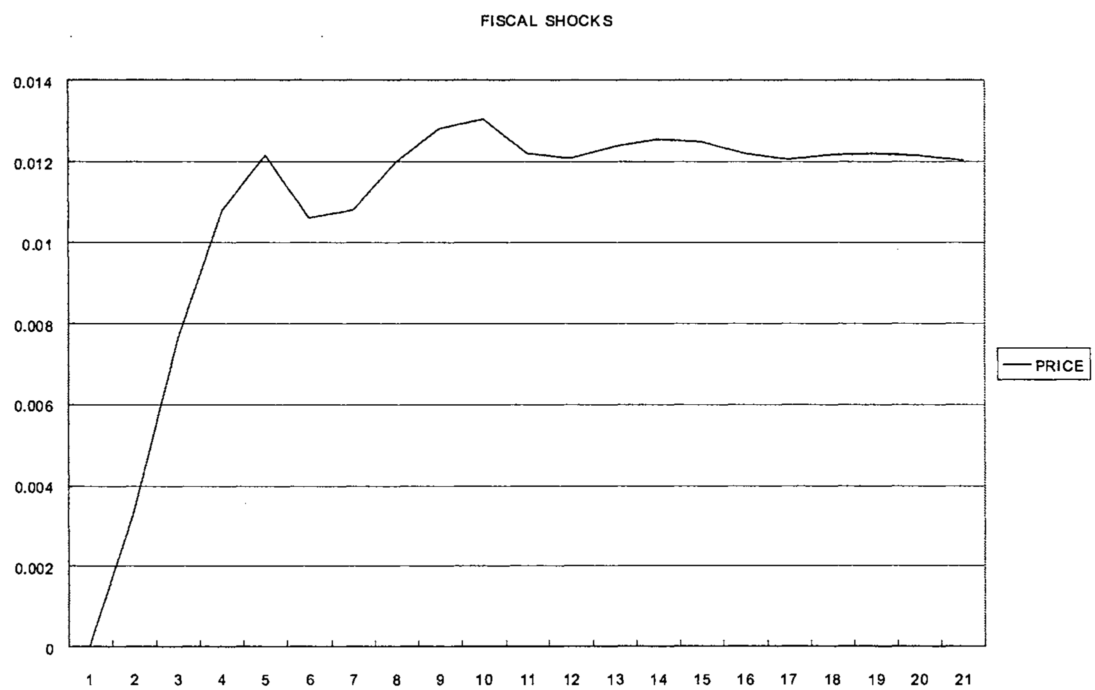


Figure 7-2 (c) Accumulated Response of Price Level to

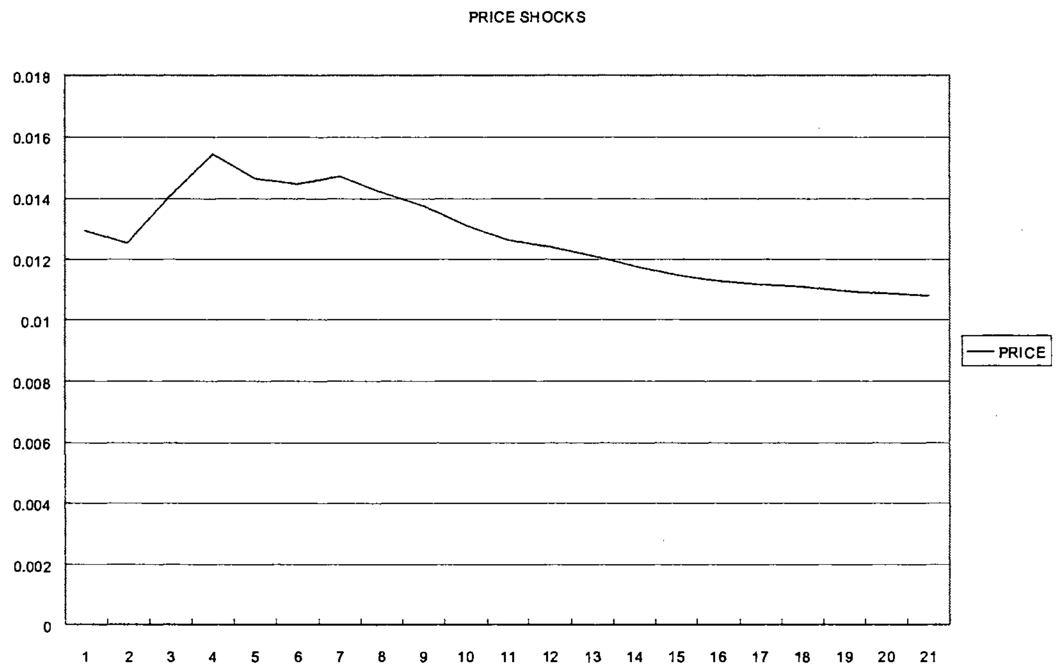


Figure 7-2 (d) Accumulated Response of Price Level to

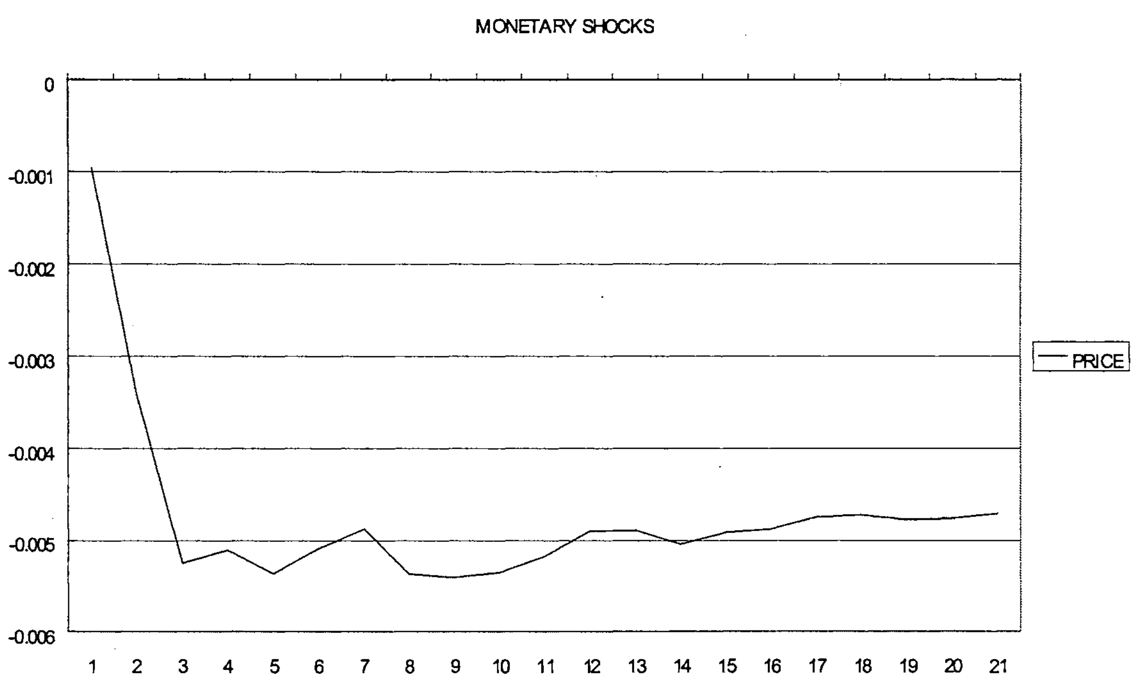


Figure 7-2 (e) Accumulated Response of Price Level to

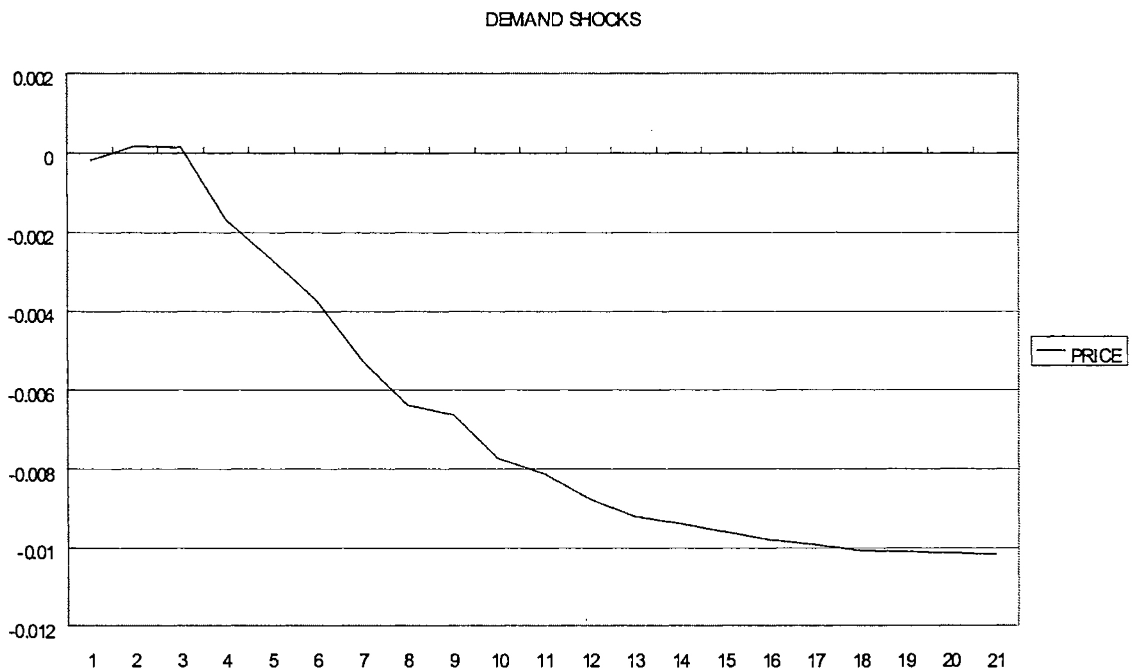


Figure 7-2 (f) Accumulated Response of Price Level to

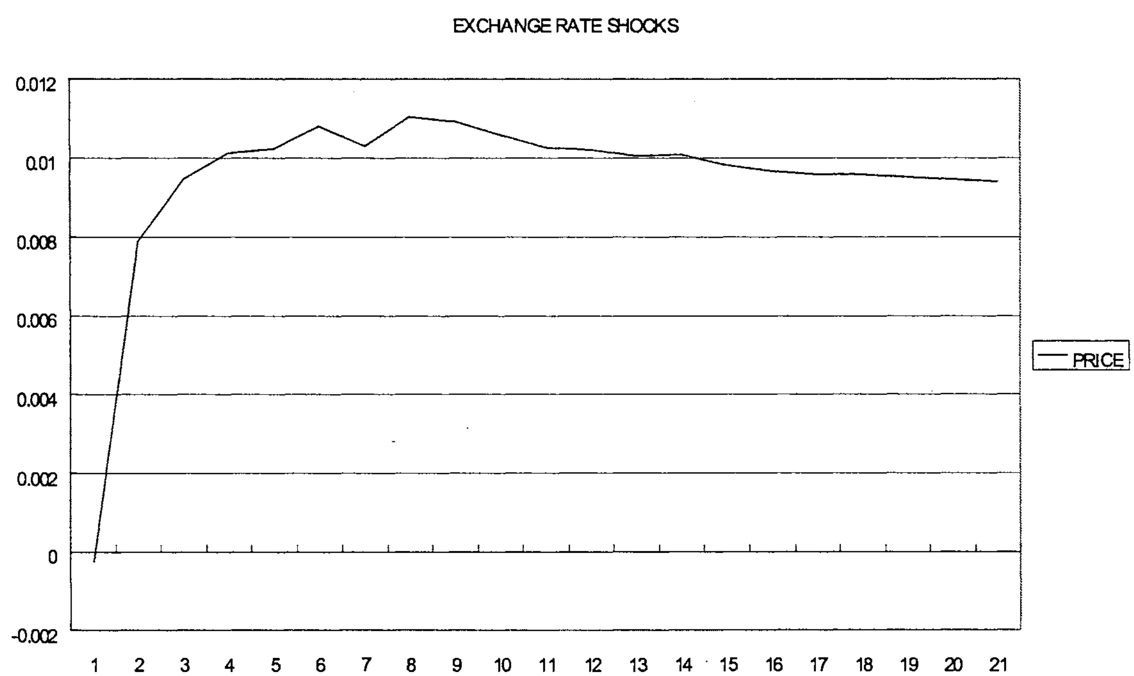


Figure 7-3 The Case of Korea

Figure 7-3 (a) Accumulated Response of Exchange Rate to

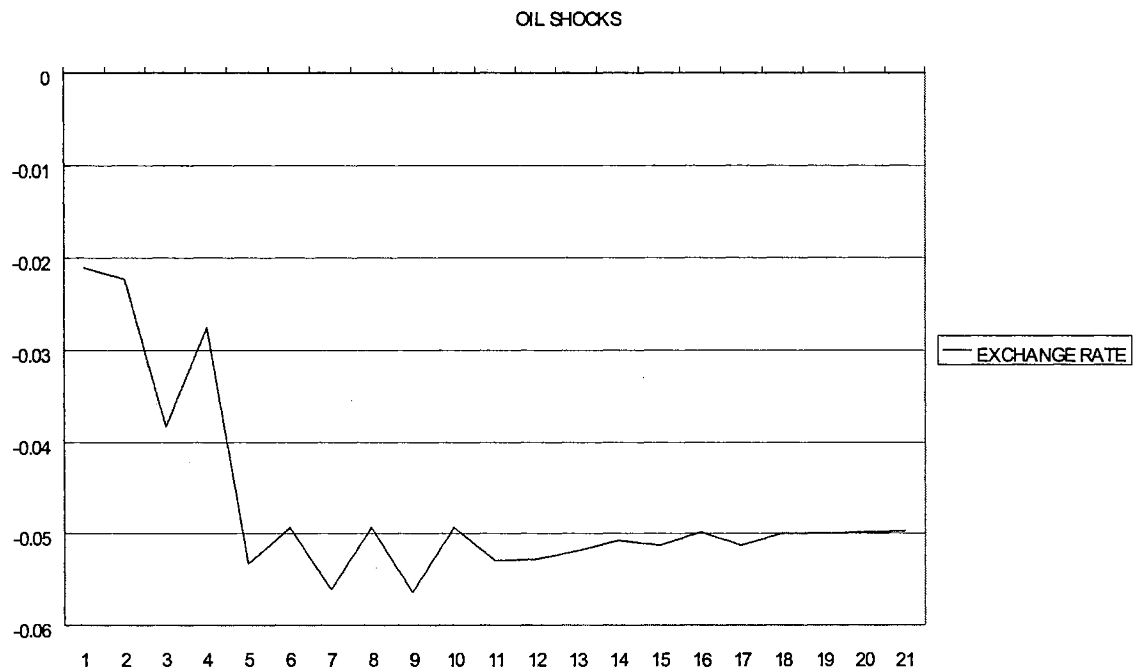


Figure 7-3 (b) Accumulated Response of Exchange Rate to

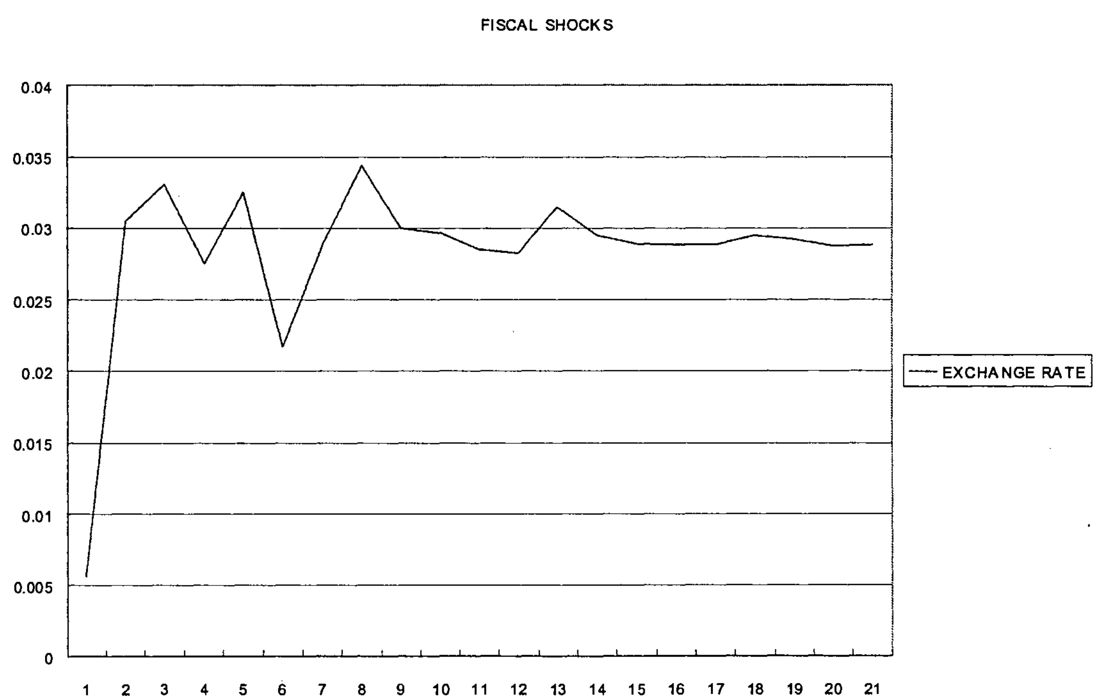


Figure 7-3 (c) Accumulated Response of Exchange Rate to

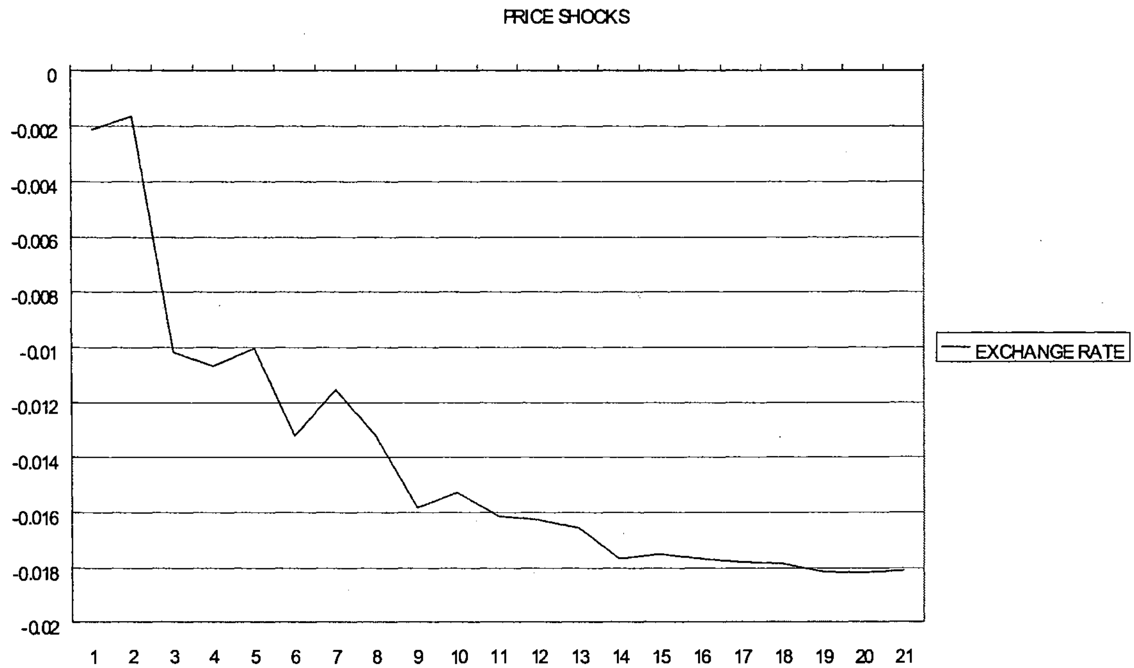


Figure 7-3 (d) Accumulated Response of Exchange Rate to

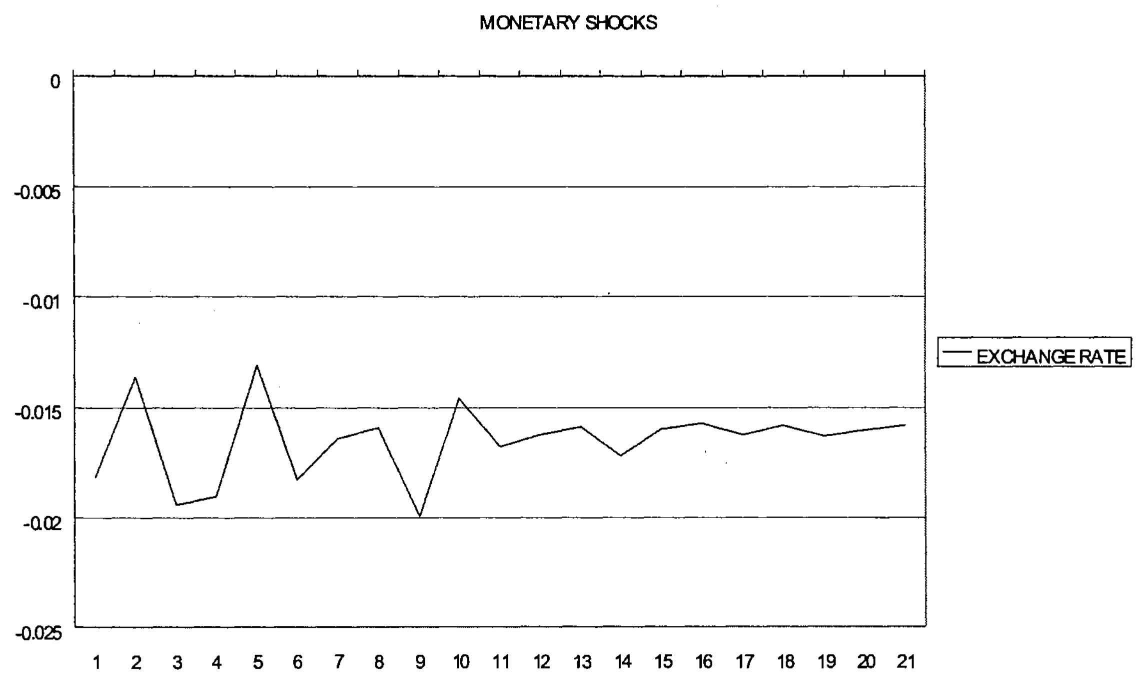


Figure 7-3 (e) Accumulated Response of Exchange Rate to

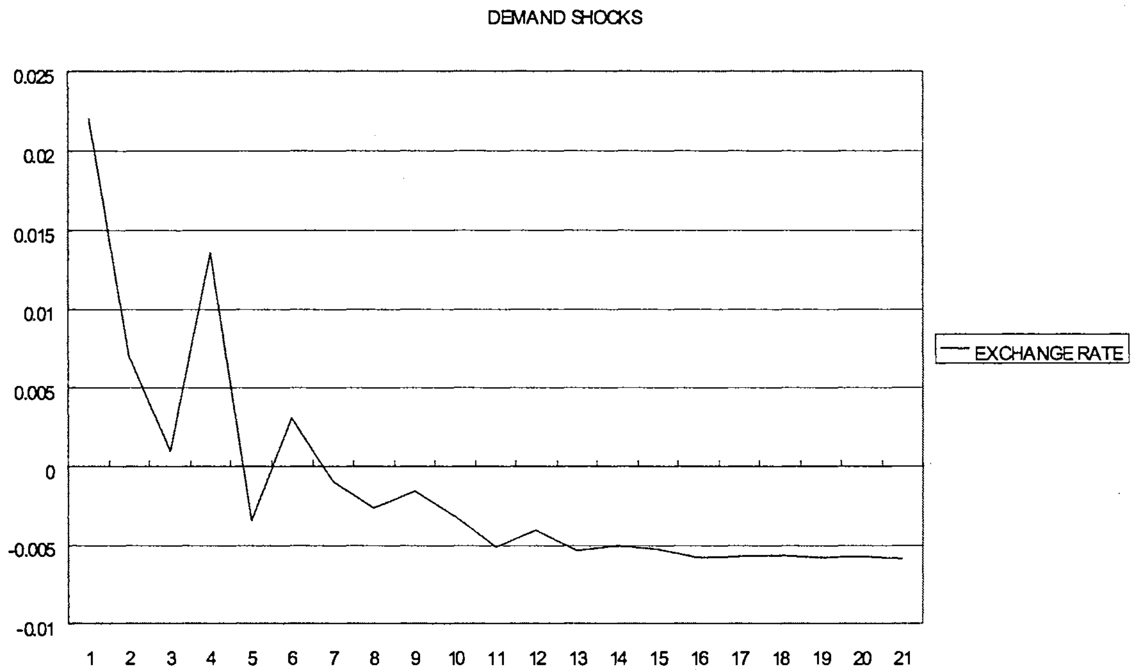
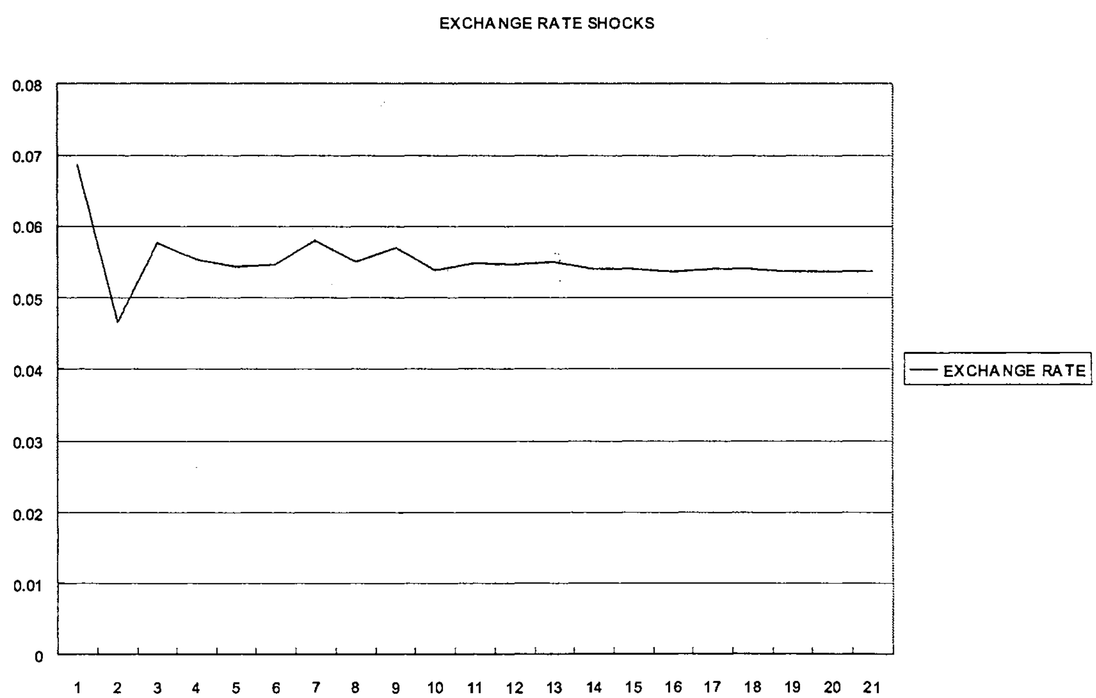


Figure 7-3 (f) Accumulated Response of Exchange Rate to



VITA (2)

Yuchung Liu

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